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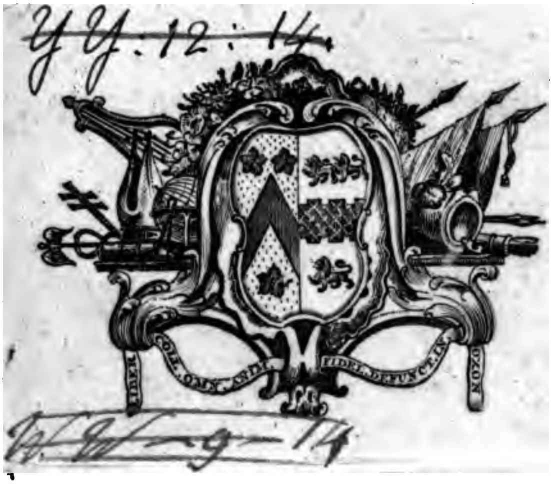
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A
GENERAL SYSTEM
OF
CHEMICAL KNOWLEDGE,

&c. &c.

A

GENERAL SYSTEM

OF

CHEMICAL KNOWLEDGE;

AND ITS

APPLICATION

TO THE

PHENOMENA OF NATURE AND ART.

BY A. F. FOURCROY,

Of the National Institute of France, Counsellor of State, Professor
of Chemistry at various Public Establishments, Member
of many Academies, &c.

IN ELEVEN VOLUMES.

TOGETHER WITH A SET OF SYNOPTIC TABLES IN LARGE FOLIO.

TRANSLATED FROM THE ORIGINAL FRENCH,

BY WILLIAM NICHOLSON.

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A
SYSTEM
OF
CHEMICAL KNOWLEDGE.

SEVENTH SECTION.

Of the Vegetable Organic Compounds.

INTRODUCTION TO THIS SECTION.

1. I HAVE hitherto treated of ſubſtances, all which belong, by reaſon of their ſimplicity or their little complicated compoſition, to the bodies which naturaliſts place in what they term the *mineral kingdom*, and which, as they compoſe the ſolid maſs of the globe, deſerve more accurately the name of foſſils. The ſubſtances whoſe hiſtory I am about to write, and which conſtitute the ſection I now commence, are of a very different nature: much more complicated than the preceding, the vegetable ſubſtances not only form a very diſtinct order of bodies, but they alſo require to be examined, and treated according to a very different method. The courſe of the ſcience ought here to differ as

well as that of nature; and inſtead of dividing this ſection, like the preceding ones, into articles placed ſucceſſively, one after the other, and placed as the neceſſary and continued ſeries of truths connected immediately with each other, the facts and the phenomena are here too complicated, and hitherto too little as yet approached to each other, and too little dependant, for it to be poſſible that I ſhould preſent them, like thoſe of the preceding ſections, in a continued and uninterrupted ſeries of articles.

2. I am therefore obliged to divide all that I have to ſay relative to the vegetable compounds into ſix orders of facts, which comprehend all the knowledge hitherto acquired, and even the ideas of what is ſtill to be acquired, reſpecting the nature, the formation, the difference, and the alterations of theſe compounds. For it is here to be remarked, that vegetable bodies are divided and ſeparated from the mineral ſubſtances by a great difference with relation to the chemical parts which compoſe them. Organic compounds in general, and thoſe which belong to the vegetables in particular, are ſtill much leſs known than the mineral ſubſtances; and though, as we ſhall ſoon ſee, modern chemiſtry has ſingularly advanced the vegetable analyſis, it has rather, as yet, acquired hopes and produced writings, than collected general reſults. The great point in the ſtudy of this beautiful department of ſcience is, to familiarize ourſelves with the well-eſta-

bliſhed and poſitive notions already in our poſſeſſion,—to acquire at the ſame time a clear underſtanding of what ſtill remains defective,—to comprehend well the means of acquiring what it wants,—to appreciate rightly the truth of the ſpeculative views to which it has raiſed itſelf,—and to become able, by means of thoſe valuable inſtruments which we begin to know how to employ, to advance this very intereſting branch of natural philoſophy.

3. The ſix orders of facts into which I divide, and under which I comprehend all that belongs at preſent to vegetable Chemiſtry, are reducible under the following heads:

The firſt relates to the ſtructure of vegetables; and the difference of this ſtructure from the texture or the maſſes of mineral ſubſtances. It would be impoſſible to form a conception of their chemical properties, if we had not an exact though preciſe notion of their organization, or the firſt cauſe of the differences which diſtinguiſh them from inorganic ſubſtances.

In the ſecond order of facts, I include what relates to the vegetable nature or compoſition in general: this is a neceſſary conſequence of their organization, which admits of a kind of combination very different from that of the minerals; and it is neceſſary firſt to know in what this difference conſiſts.

To the third order belongs the kind of action which the principal ſubſtances already examined exert upon vegetables; that is to ſay, the chemical characters which they preſent, by means of which we diſcover their nature, and determine their compoſition.

The fourth order of facts comprehends the examination of all the ſubſtances which are extracted from vegetables, which really conſtitute them, and which on that account are called the *principles* or *immediate materials* of vegetables. This is the longeſt, and requires the moſt details, becauſe it is the moſt abundant in facts, upon which the moſt labour has been beſtowed, and has hitherto ſolely conſtituted the vegetable analyſis.

In the fifth order I rank the expoſition and ſtudy of the different natural alterations to which vegetables are liable, and which, being dependant upon their compoſition, are at the ſame time very proper for acquainting us with its nature.

Laſtly, to the ſixth order of facts I refer what I term the phenomena of vegetable life, or the application of all the facts preliminarily explained in the preceding orders, to the vegetable phyſics. This laſt, which is the complement of all the reſt, the object to which they manifeſtly lead, is one of the moſt beautiful reſults of modern chemiſtry.

Firſt Order of Facts relative to the Vegetable Compounds.

Concerning the Structure of Vegetables, and the Phyſical Differences which diſtinguiſh them from inorganic Bodies.

ARTICLE I.

Of the external or apparent Structure of Vegetables.

1. THE firſt obſervations which man, placed upon this earth, could make upon the productions of nature around him, muſt have ſhowed him that vegetables differed in a remarkable manner from the ſubſtances which form the maſs of the globe in their appearance, ſtature, aſpect, and all the properties which quickly characterized them to his eyes. When he wiſhed to account for the difference that had ſtruck him, he could not fail to remark in particular the variety and the diſſimilarity of their parts, and the diverſity of form in the different points of their ſurface; whilſt the ſtone, the pebble, the mineral and the foſſil, of whatever nature they might be, preſented to him a perfectly uniform whole, a maſs homogeneous throughout all its continuity.

2. When we wiſh to define a vegetable, we are obliged to conſider it as a compound of different diſſimilar parts, which are deſignated by the names of *root*, *ſtalk*, *leaves*, *flowers*, *fruits*, and *ſeeds*. The vegetable which preſents all

theſe parts, developed ſucceſſively and at different periods of its life, is called a *perfect vegetable.* Thoſe in which ſome of theſe parts are wanting are termed *imperfect.* There are ſome plants which ſeem to be nothing elſe than roots, ſuch as the truffles, and others which want them, as the lichens, &c. There are ſome which have no leaves, and ſeem to conſiſt merely of ſtalks and branches, whilſt others have only leaves without ſtalks: ſome preſent very diſtinct and eaſily recognizable flowers; others preſent no organs that can be conſidered as flowers, though there are, in fact, no vegetables that are really deſtitute of them. In the one, we eaſily obſerve the fruits and the ſeeds; in the others we find no parts that reſemble them. However, the number of vegetables which contain all theſe parts is ſo conſiderable, and they appear to be ſo conſtant, and ſo deeply connected with the nature of vegetable, that we are induced to believe that even thoſe which ſeem to be totally deprived of them, preſent, when attentively examined, parts which might be conſidered as real flowers or fruits neceſſary to the re-production and the propagation of the ſpecies.

2. The root, which is moſt frequently buried in the ground, ſometimes immerſed in the water, or penetrating the texture of various other vegetables, ſupports the whole plant; it takes up and conducts into the vegetable a large portion of its nouriſhment, by the fibrils which

are termed capillary, and which may be conſidered as abſorbent veſſels, as mouths deſtined to ſuck in the juices of the earth and of the manures. Botaniſts diſtinguiſh roots according to their form, texture, and ſituation, into the tuberous, the bulbous, the fibroſe, the contorted, the repent, the horizontal, the oblique, the rounded, the irregular, the conical, the cylindrical, the fuſiform, the articulated, the palmated, the fleſhy, the woody, &c. &c. Theſe differences have even been frequently employed by them to ſerve as characters of different ſpecies.

4. The ſtem which proceeds immediately from the root, with which it appears to be continuous, though it is of a very different ſtructure, is the general ſupport of all the parts: it is termed *trunk*, when it is bulky and ſolid; culm or ſtraw, when it is hollow; ſtalk, when it ſupports a flower: it is round, ſquare, triangular, ſmooth, viſcous, canulated, ſtraight, inclined, bent, articulated, pithy, &c. it is divided into branches, and theſe into boughs. The trunk of a tree is diſtinguiſhed into wood and bark; the wood into ligneous ſubſtance and alburnum or ſap; the bark into Epidermis and cortical layers. Botaniſts make uſe of the remarkable differences of this part in order to deſcribe and characterize vegetables. According to this they diſtinguiſh trees, ſhrubs, the woody plants, the herbaceous plants, the gramineous plants, the reeds, the ruſhes, &c. &c. it affords many characters, ſpecies, and varieties. It is alſo, in this part, the

general ſupport of all the reſt, that we beſt perceive the internal ſtructure, the real anatomical texture of vegetables, and that we obſerve the principal phenomena of their organization and functions, as I ſhall ſhow in the following article.

5. The leaves, a kind of flat tiſſues, which ſeem to be laminated branches, compoſed of the ſame internal parts as the ſtalk, the ornament and verdant clothing of the vegetable, organs deſtined to entertain by their multiplied ſurface immenſe communications with the atmoſphere, conſtitute the parts which differ the moſt from each other, and which furniſh at the ſame time the greateſt number of notions to be acquired, and the greateſt part of the deſcriptive characters which botaniſts can employ in order to diſtinguiſh the ſeveral ſpecies. The leaves differ:

a. With reſpect to ſize; ſome are of an enormous extent; others are ſo ſmall that they are ſcarcely diſcernible.

b. With reſpect to form: they are oval, round, linear, elliptic, triangular, ſquare, tetrahedral, hexahedral, oblong, ſemi-lunar, pointed, truncated, lanceolated, ſagittary, cuneiform, lyre-ſhaped, cylindrical, in the form of priſms, &c.

c. With reſpect to their contours or their margins, they are even, dentated, channeled, angular, undulated, truncated, laciniated, ſmooth, wrinkled, circled, edged with various colours, &c.

d. With reſpect to their appendages: they are naked, armed, briſly, thorny, hairy, downy, aculeated, hamous, rugous, granulous, glandulous, tuberculous, &c.

e. With reſpect to their ſurfaces, or the upper and the lower ſide: they are ſmooth, poliſhed, varniſhed, brilliant, dull, even, unequal, ſinuous, perforated, porous, with holes, flat, convex, concave, caniculated, in the form of a cup, curved, &c.

f. With reſpect to colour: light-green, dark-green, red, ſpotted with veins, clouded, of a ſingle colour, verſicolor, painted, diverſified, eſpecially in their two ſurfaces, &c.

g With reſpect to their ſimplicity or compoſition: they are ſimple or three-fold, four-fold, lobous, &c. The compound leaves have leaflets arranged oppoſite to each other, when they are termed oppoſite, or without being oppoſite to each other, when they are alternate; either with or without an odd leaflet, which terminates them: they are called palmated, pinnated, bipinnated, tripinnated, according to the order of their compoſition.

h. With reſpect to the manner in which they are attached to the ſtalk; they are ſeſſile, petiolated, oppoſite, alternate, verticillated, amplexicaulate, perfoliated, vaginated, &c.

i. With reſpect to the ſituation which they occupy in the plant; they are radical, caulinary, floral, axillary.

k. With reſpect to their conſiſtence; they are ſoft, dry, papyraceous, ſilky, thick, fleſhy, fat, or coriaceous.

h. With reſpect to their taſte and ſmell: they are herbaceous, inſipid, ſweet, ſaccharine, auſtere, acid, bitter, aſtringent, acrid, cauſtic, burning, inodorous, aromatic, fragrant, ambroſiacal, fetid, virous, alliaceous, reſembling ſome known odours, vulvary, ſtercoraceous, urinous, having the ſmell of roaſted fleſh, &c.

The ſupports which bear and attach them, or the petiolæs, which are continuous with the ſtalk or the branches, containing in contiguity with each other the veſſels which ſpread themſelves between their two ſurfaces, vary alſo greatly in their length, their thickneſs, their form, their colour, their nakedneſs, their defences, &c.

6. The flowers, precious organs, the maſter-piece of the vegetable creation, the nuptial-bed which incloſe and conceal the connubial rites of the plants, are compoſed of parts which defend the organs of generation, and of theſe organs themſelves. When they contain both the external coverings and two ſexes, they are termed *complete* and *hermaphrodite*; when they are deprived of ſome, they are ſaid to be incomplete, male, female, with fruits, &c. The external parts, a kind of integuments, which defend or ſupport the internal, are the calix, the receptacle, the corolla, and the nectary; the internal parts, the genital organs, are the ſtamens and the piſtil.

A. The calix, the outermoſt and the thickeſt tegument, a continuity of the bark, the green colour and texture of which it generally poſſeſſes, is called the *Perianth* in moſt of the flowers, which it ſurrounds like a vaſe; *ſpathe,* in the liliaceous plants, in which it quits the flowers which raiſe themſelves above it, dries, drops off, or diſappears; *chaff* or *glume* in the gramineous, in which it has the form of a ſimple ſcale; *involucre* in the umbelliferous, in which it connects and incloſes the parcels of flowers by its lineary and filamentous diviſions; *catkin,* or a falſe calix; a conical or cylindrical ſupport of a great number of monoecial or dioecial flowers; veil in the moſſes; hood in the muſhrooms. The calix is uniflorous or multiflorous, partial or common, hard, ſoft, permanent or deciduous, drying or ſwelling, in order to become the fruit, extremely varied in its form, its ſize, and all its properties; it is rounded, globular, cylindrical, dentated, divided, monophyllous, polyphyllous, ſimple, double, triple, ſmooth, canulated, ſpinous, hairy, glandulous, open, dilated, cloſed, contracted, &c, Rivinus, and ſeveral other botaniſts, have founded a method, or regular claſſification of vegetables, upon the ſtructure of the calixes.

B. The receptacle, a ſort of plate that terminates the ſtalk, of which it is commonly nothing elſe than the extremity dilated into a button, forming ſometimes a diſtinct and enlarged fleſhy maſs, ſupports all the parts of the flower; the calix which forms its external circle, the border, and frequently envelope the corolla in a ſecond circle, the ſtamens in a third, when they are attached to the receptacle, the piſtil in the centre. Sometimes the receptacle ſupports the ſeeds uncovered after the flower; ſometimes it ſerves as a covering for it, and forms the fruit with the calix which remains, either entirely or in part, ſolidly adhering to it.

C. The corolla, a membrane of the flower, generally coloured and brilliant; that which ſtrikes the eye the moſt, attracts the moſt notice, and really conſtitutes the flower in the opinion of the majority of mankind; a ſemi-tranſparent veil, which is in the neareſt contact with and ſupports the male organs of generation, continuation of the liber, or the cortical layers, is one of the parts which has moſt engaged the attention of botaniſts. It conſiſts either of a ſingle piece, in which caſe it is termed *monopetalous,* or of ſeveral pieces, when it is called *polypetalous.* Both of theſe corollas are either regular or irregular. The regular monopetalous corolla is termed campaniform when it reſembles a bell; infundibuliform when it reſembles a funnel. The irregular monopetalous corolla is *labiated* when it preſents the appearance of two lips at its orifice. The regular popetalous corolla is in the form of a croſs, *cruciform*; of a roſe, *roſaceous*; of a pink, *caryophyllated*; of a lily, *liliaceous*; of a butterfly, *papil-*

papilionaceous, or *leguminous*; both of them when without any determined form are termed *anomalous*. When the monopetalous coralla is very ſmall, and forms a long ſtraight tube, united in the ſame calix with many others, and terminated by five teeth, it is termed *floſculus*; when it is ſhaped into a tongue at its extremity, it is called *ſemi-floſculus*. The flowers that have no corolla are termed *apetalous*. In the petal, or each piece of the polypetalous flower, are diſtinguiſhed the claw *unguis* or narrow baſe by which it is inſerted, and the border or dilated part.

Linnæus compares the corolla with the curtains of the bed that conceal the married pair. When it is blown the fecundation is generally effected. Tournefort has founded his ſyſtem of botany upon the form of the corolla.

D. The nectary is an appendage or part of the corolla, which contains a ſaccharine and aromatic juice, called *nectar*, of which inſects, eſpecially bees, are very greedy, and which they form into honey. This organ is frequently a ſmall cavity, a ridge, a groove, one or more glands, a ſmall open round capſule, a fiſſure; ſometimes it is formed of branched hairs, a kind of tufts, horns, cowls, veſſels, ſpurs, cylinders, &c.; it exiſts in all corollas. The bottom or folds of thoſe which preſent no very diſtinct and well formed nectary, ſupply the place of it, and are found filled with a ſaccharine juice which filtrates in them.

E. The ſtamens, the male organs of generation in plants, form one of the moſt eſſential parts of the flower. When they are alone, the flower is ſaid to be *male* : they generally conſiſt of the *filament* and the *anthera*. The firſt is a ſnpport through which the nouriſhment is conveyed to the anthera; the latter is a ſmall bag filled with fecundating powder or *pollen*; ſometimes the anthera has no filament. Modern botaniſts have much ſtudied the ſtructure and the diverſities of this important part of vegetables. They have diſtinguiſhed in it, eſpecially *a.* The number, which varies in different genera of plants, from one to ſeveral ſcore; *b.* The reſpective heights, which is either equal or unequal; in the latter caſe, when there are two large and two ſhort, they are termed *didynamic;* when there four large and two ſhort, they are *tetradynamic; c.* The form of the filaments, the form and the number of the anthers; *d.* Their ſeparation or their union; this is formed by means of fibres, when the name of *adelphia* is applied to them in general; *monadelphia* when they are united into a ſingle maſs; *diadelphia* when they conſtitute two; and *polyadelphia* when they form more than two bodies. The union is ſometimes effected by the anthers, they are termed *ſyngeneſia; e.* Their attachment, either to the receptacle, or upon the ovary, or to the calix, or to the corolla. The laſt mentioned inſertion always takes place when the corolla is monopetalous. Theſe poſitions are characterized by three modes of expreſſion. The ſtamen is ſaid to be *epigynous*, when it is attached above the germ, or to the germ itſelf; *hypogynous* when it is beneath, or adhering to the receptacle; *periginous* when it is round, or inſerted upon the calix. When the monopetalous corolla is ſtaminiferous, its inſertion, which then determines that of the ſtamens, is likewiſe triple. Linnæus invented an ingenious ſyſtem according to the number, the reſpective ſize, the ſituation, &c. of the ſtamens; and Juſſieu has eſtabliſhed a ſtill more profound and learned one, upon the manner in which the ſtamina are inſerted into the different parts of the flower.

F. The piſtil, the female organ of generation is placed in the centre of the flower: it conſiſts of an inferior part or *ovary*, a ſort of box or capſule, which contains the ſeeds, or determined by the ſeed or the ſeeds, even expoſed in the bottom of the flower. This firſt part is ſurmounted with a cylindrical canal, more or leſs long, termed the *ſtyle;* the gardeners term it the ſhaft in fruit trees; it has at its extremity, a kind of head, button, or horn, or a ſomewhat dilated aperture, known by the name of *ſtigma.* Sometimes the ſtigma, without any intermediate ſtyle, is ſupported immediately upon the germen or ovary; in this caſe, it is termed a *ſeſſile ſtigma.* Since the ſtamens have been more ſtudied, the ſame attention has been beſtowed upon the ſtyle, and the multitude of differences have been found, and indicated in it. The number, the form, the reſpective poſition of each part of the piſtil has given riſe to the adoption of a long ſeries of diſtinctions: the poſition above or below the calix and the flower, has particularly been remarked; this is a conſtant and very remarkable character of vegetables. Linnæus has alſo taken the conſtant varieties of the piſtils in different vegetables, for the eſtabliſhment of his ſyſtem, and he has made them conſtitute the character of moſt of his orders, or of the diviſions of his claſſes.

7. The relative poſition of the flowers is alſo one of the facts which moſt influences the appearance and the external ſtructure of the vegetables; they are either ſeſſile, placed immediately upon the branches or twigs, or pedunculated, that is to ſay, ſuſtained by a peduncule or ſupport, more or leſs long, ſhort, ſtraight, crooked, rigid, pliable, inclined, moveable, agitated, ſtrong or weak, capillary, &c. They are either ſolitary, or arranged two and two, three and three, four and four, axillary, terminal, caulinary, verticillated, in ſtages, in ears, in umbellæ, in cluſters, in corymbuſes, in thyrſuſes, in bouquets, in faſciæ, in paniculæ, in heads, balls, pyramids.

8. The fruit, which ſucceeds the flower, the laſt term in the work of vegetation, deſtined to perpetuate the ſpecies by the ſucceſſion of the individuals, is formed of one or more naked ſeeds contained at the bottom of the calyx, or

of ſeeds ſolidly incloſed until their maturation, in coverings, which have been diſtinguiſhed according to the difference of their ſtructure into ſeven ſpecies. Four of theſe grow dry as they arrive at maturity; they are termed *capſule*, when the ſeeds are contained in them without attachment; *ſilique* or pod when they are attached to two ſkins or valves ſeparated by an intermediate partition; *huſk* or *legume* when between two ſkins or valves without partition, they are inſerted on a ſingle ſide; *cone* when they are placed upon a conical axis, and covered with ligneous ſhells which defend them. Three other ſpecies of fruits remain ſucculent; namely, the *nuts* or the kernel fruits, covered with pulp; the *apples*, or fruits with pepins, provided with a thick and tender parenchima; the *berries*, with a ſoft and ſemi-liquid pulp, in which the ſeeds are inſerted without apparent order or attachment, *ſemina nidulantia*. All fruits open at a certain period, either by the drying of their ſkins, and their elaſtic ſeparation, which throws out and ſows the grains, or by the decompoſition of the pulp which conſtitutes them, or by the ſwelling and laceration of the woody ſhells or horny capſules which incloſe the ſeeds. Methods or ſyſtems of botany have alſo been founded upon the ſtructure and the difference of the fruits.

9. The ſeeds, the moſt admirable and moſt incomprehenſible part of vegetables, which contain them, completely formed within a very

ſmall volume, are in general compoſed of three ſubſtances: the *embryo*, the *cotyledon* or *cotyledons*, and the *periſperma*. Theſe three interior ſubſtances are enveloped in a thin and light pellicle, which is itſelf covered with a ſolid tegument, frequently horny or cartilaginous. The latter is alſo almoſt always provided with a fat, glutinous, reſinous, or mucous powder, which defends it againſt the action of external ſubſtances. This whole apparatus, which is alſo termed *grain*, varies prodigiouſly with reſpect to ſize and form. Some ſeeds are very large, whilſt others elude the ſight. They are ſpherical, rounded, compreſſed, ovoid, lenticular, cylindrical, reniform, ſubtriangular, ſubtetragonal, compreſſed, flattened, ſmooth, poliſhed, varniſhed, rough, rugous, furrowed, canulated, ſtriated, ſculptured, naked, dentated, thorny, in the form of ſails, wings, tufts, plumes, pointed, edged, &c. &c.

A. The *embryo*, which is alſo termed the *plantula*, or *corculum*, contains the plumula, the radicle, and a part intermediary between both; it adheres to the cotyledon by one or two ligaments, which are compared with the umbilical cord in animals. It is a vegetable ſimilar to that which has given birth to it, the folded and implicated parts of which are to be developed by germination.

B. The term *cotyledon* implies a white, brittle, granulated ſubſtance, of a fine texture, which is eaſily reduced to powder, to which the embryo adheres. There are ſome plants in which it has not yet been poſſible to aſcertain its exiſtence, on account of the extreme ſmallneſs of their ſeed; theſe are termed *acotyledonous.* There are ſome in which this part conſiſts of a ſingle piece; theſe are termed *monocotyledonous.* Many contain two very diſtinct cotelydons, which may eaſily be ſeparated from each other; theſe plants are diſtinguiſhed by the name *dycotyledonous.*

C. The *periſperma* is a third ſubſtance comprehended in the internal texture of ſeeds, almoſt always ſmaller than the cotyledons, more contiguous to the plantula, frequently ſurrounding it entirely, lodged together with it in the cotyledons, from which it is diſtinguiſhed by its colour, its texture, its taſte, which is almoſt always acrid, whilſt that of the cotyledons is generally inſipid or mild. This ſubſtance is oleaginous, or carneous, or farinaceous, &c. It has not been well diſtinguiſhed and deſcribed, except by the moſt modern botaniſts.

10. It is evident from this rapid ſketch, which, however, is perfectly ſufficient for the comprehenſion of all that relates to the chemical analyſis of vegetables, that this apparent and external ſtructure already eſtabliſhes a very remarkable diſtinction between theſe bodies, and thoſe of which we have hitherto treated. It is not only by the great diſſimilarity of the parts of which plants are compoſed, whilſt all the points of the ſame foſſil are exactly ſimilar to

each

each other; but ſtill more eſpecially by the intimate contexture, or the peculiar organization of theſe parts; that theſe beautiful productions of nature are ſtill much farther removed from the mineral ſubſtances. It has formerly, but in vain, been attempted to eſtabliſh pretended analogies of ſtructure between the moſt regular foſſils and the moſt ſimple of the plants; in vain has it been endeavoured to ſupport theſe analogies by the figured ſtones, the ſtony dendrites, the herborizations, the fibrous ſtones termed foſſil linen, the configurations of ſtones and metals in fern-leaves, &c. Cryſtallization itſelf, a ſort of regular and conſtant geometrical arrangement of the molecules of minerals with reſpect to each other, in which ſome moderns have imagined they perceived a kind of almoſt organized ſtructure, is very far from being able to be confounded with the moſt ſimple of the vegetable organizations. This truth will be placed in the cleareſt light by the expoſition of the moſt ſimple notions, concerning the internal ſtructure, or the anatomy of plants.

ARTICLE II.

Of the internal Structure or Anatomy of Vegetables.

1. ALL the parts of vegetables deſcribed in the preceding article, which preſent themſelves at the mere view of theſe organized beings,

which require no preparation or deſtruction in order to be obſerved or known, preſent in their internal parts, when diſſected, a ſtructure, a tiſſue, in a word, an organization widely different from the ſimple laminæ, or the cryſtalline and homogeneous molecules which conſtitute the foſſils. No one can fail of acquiring an idea of this difference, even in the exerciſe of the moſt ſimple arts, and in the moſt ordinary operations of life. In fact, when we wiſh to deſtroy the texture of any vegetable ſubſtance, we are obliged to go to work in a very different manner than when we break or pound a foſſil: the latter requires only a ſtroke or preſſure, and divides or elongates itſelf into molecules or ſurfaces that are ſimilar or perfectly identical. The vegetable, much leſs denſe in its texture, may eaſily be bent, momentaneouſly compreſſed, or even fractured by the efforts of the hands, by ſtroke, or by preſſure; but the neceſſity of cutting it, reducing it into fragments dividing it into pieces, extracting from it the liquids, which alſo are not found in the foſſils, has given riſe to the invention of wedges, axes, bills, knives, ſcythes, ſickles, ſaws, planes, chiſels, preſſes, and a number of other inſtruments; of which the mere uſe ſhows to the moſt uninſtructed workman, that the organized ſtructure of plants is extremely different from that of the ſtones, ſalts, or metals.

2. When the philoſopher was deſirous of making himſelf acquainted with the vegetable organization,

ation, when he inveſtigated the texture of theſe bodies, with the aid of delicate inſtruments, by ſections made in different directions, the regular ſeparation of their fibres and layers, by means of maceration in water, of the moderate action of fire, and of the obſervation even of the phenomena and accidents which vegetables preſent during their life; when, I ſay, he inveſtigated the mode of this organization, he ſoon diſcovered that their different parts were a regular or co-ordinate aſſemblage of ſolid fibres, of channels or hollow veſſels, of liquids which circulate through them, of veſſels which receive them, of orifices which filtrate them either outwards or into cavities of internal reſervoirs, and that all theſe veſſels, intertwined with each other, and communicating amongſt themſelves, were the product of an infinite development, of a growth by intuſ-ſuſception, entirely different from the ſimple juxta-poſition which obtains in the minerals.

3. The labours and diſſections of Malpighi, Grew, and Duhamel, relative to vegetable anatomy, have ſhown that plants are formed of five orders of veſſels different in their organization, contained beſides in larger or ſmaller quantity, and diſpoſed amongſt themſelves in a particular manner, whether with reſpect to their reſpective arrangement, or to their number, in the different parts that have been deſcribed in the preceding article. The five orders of veſſels are, 1. The common veſſels; 2. the proper veſſels;

3. the tracheæ; 4. the utricles; 5. the veſicular tiſſue. It is eſſentially neceſſary, in order to acquire an exact and general notion of the internal or anatomical ſtructure of vegetables, to make one's ſelf well acquainted with the organization of theſe ſyſtems of veſſels, the aſſemblage of which forms their texture.

4. Common or ſap-veſſels are thoſe which are conſtantly found in all vegetables, in all their parts, and which are deſtined to convey the ſap. In general, a large part of them are collected in the ſtalk of plants, or the trunk of trees; they elevate themſelves perpendicularly from the root to the ſummit of the vegetable; they turn themſelves laterally in all directions, leaving between them meſhes, or net-work, more or leſs contracted or dilated. It is not yet known whether theſe are real hollow channels, continued in their whole length, interrupted by kinds of hairs or valvules, as ſome phylologiſts have ſuppoſed; whether the ſap is contained in their interior part, or whether it does not rather run upon the grooves or the external cavities with which they ſeem to be furrowed. It is generally believed that they pour this liquid into the utricles and the proper veſſels: beſides the ſap, they alſo in ſome caſes convey elaſtic fluids. It is the layers and parcels of theſe veſſels which conſtitute the wood properly ſo called, or at leaſt which every where accompany it.

5. The proper veſſels are ſo named becauſe they are filled with juices peculiar to each vegetable,

getable, or to each part of the ſame vegetable. Theſe are real ſecreting organs, which ſeparate and retain, like real inſulated reſervoirs, the different humours of a particular nature, which ought not to be mixed with the common juice. They are almoſt always ſituated under the bark; round and below the firſt cortical layers; they are diſtinguiſhed, when a ſtalk is cut in a direction perpendicular with its axis, by the drops of different coloured liquids, very diſtinct from the ſap, which exſude from their open extremities. Sometimes they are dilated into veſicles or a kind of cells. They are connected with the common veſſels.

6. The tracheæ, or air-veſſels, are ſo termed on account of their reſemblance with the organs which in inſects are deſtined to tranſmit the air into every part of their bodies. Theſe are very ſmall filaments, more than capillary or ſetaceous, brilliant and ſilky at their ſurface, twiſted into narrow ſpiral forms or worms, placed eſpecially between the common veſſels, and frequently running through and often filling up their intervals. They are diſtinguiſhed in a piece of wood ſawed or cleft longitudinally, by the ſmall luminous lamellæ or ſpots, of a micaceous and argentine colour, which ſhine from all parts upon the ſurface of the wood, eſpecially when it is expoſed to the ſun. They are obtained, inſulated, and we obſerve them with their ſpiral ſtructure very diſtinctly in the young twigs of the roſe-ſhrub, when torn

aſunder, and not entirely filled. Though they ſeem to be deſtined to convey the elaſtic fluids, the tracheæ are frequently found full of ſappy juice.

7. The utricular texture, compoſed of ſmall irregular ſacs, ſoft and compreſſible, full of thick juice, are found collected in the pith of the ſtalks; they appear to receive from ſap-veſſels, and to tranſport from thence into the proper veſſels, the humours which they elaborate in their cavities, and to be eſpecially deſtined for the purpoſes of nutrition. Theſe are the great terminations, or the centres of the abſorbent veſſels, like the thoracic duct or ducts in animals. Frequently they are filled with coloured juices. There are many vegetables in which this part becomes obliterated, and is afterwards ſupplied only by the veſicular texture. Moſt of the plants, with a hollow or porous ſtalk, preſent an admirable ſtructure in the faſciæ of utricles, which occupy their centre. The nutritive matter is particularly contained in this texture, as in a reſervoir.

8. The veſicular or cellular texture is merely an expanſion, or a prolongation of the preceding texture. From the circumference of the utrico-medullary faſces proceed continued utricles, which paſſing horizontally through the meſhes or areolæ left by the croſſings and lateral divarications of the common veſſels, proceed, diverging or elongating themſelves, to ſpring forth above and on the outſide of the

cortical layers under the epidermis, where they pour out the reparatory juice which forms theſe layers. This ſtructure is very marked, and very eaſy to be diſcerned in all the herbaceous plants, and in young woody plants. Very ſenſible traces of it can be ſeen in the hardeſt and oldeſt wood: ſuch are thoſe ſtellated rays, which in the trunk of a tree ſawed through perpendicularly with its axis, proceed from the centre, and loſe themſelves under the bark. Between each layer of common veſſels, this cellular texture, which is ſo analogous to the cellular texture of the bodies of animals, forms an expanſion of a more rare or leſs denſe ſtructure than theſe vaſcular layers, which is preſerved flexible and elaſtic by the nutritive juice, which is there poured out.

9. From the aggregation and arrangement of theſe five orders of veſſels reſults the organization of the different parts which compoſe the bodies of vegetables; and nothing is more proper than this conſideration, to prove that this ſtructure is extremely remote from the ſimple juxta-poſition of the laminæ or the ſolids which conſtitute the foſſils. In theſe the diſpoſition of their molecules, even when regular and geometrical, depends only upon their primitive form, and their mutual attraction, modified by all the external circumſtances which favour or diminiſh their equillibration, their approximation, their coheſion. At whatever point of their continuity we examine the contexture of

the parts of a foſſil, whatever it may be, we always find only ſimilar molecules or particles; in plants on the contrary, we perceive, at different points of their texture, diſſimilar veſſels, different organs, particular and different diſpoſitions of theſe veſſels, communications, continued orifices of tubes or veſſels, which preſent themſelves to the obſerver.

10. It will not, however, be ſufficient to confine ourſelves to this general conſideration of the intimate ſtructure of vegetables, in order to acquire an accurate idea of the differences which diſtinguiſh them from the minerals. We muſt alſo inquire what differences this internal organization preſents in each of the ſix different articles, of which it has been ſaid in the preceding article, that a perfect vegetable, or one complete in its organization, is compoſed.

A. The fibrous root has the ſame texture, the ſame organization as the ligneous trunk or the wood: only its bark is never dry and hard, nor covered with a ſolid dry epidermis like that of the trunk. Moreover we find in it numerous filaments or fibres, filled with a multitude of abſorbent veſſels, deſtined to ſuck in the water and what it takes up from the earth, like ſo many ſyphons. In the carneous or tuberous root we ſee no ligneous layers, but a ſpecies of parenchyma lodged in a conſiderable maſs of utricles or cellular texture.

B. The ſtalk, or the trunk, is the part of vegetables in which we are beſt able to diſcern their texture and organization, eſpecially in that which is ſolid and ligneous, and which belongs to the trees. In this ſtalk we diſtinguiſh the bark and the wood. The bark, or the external tegument of the wood, and of all the parts of vegetables, is formed, eſpecially in trees, where we can ſee and detach it diſtinctly, of two very diſtinct parts, namely, the dry membranous epidermis, of a dark-grey, whitiſh or yellowiſh colour, compoſed of ſmall, brittle, ſemi-tranſparent plates; and the cortical layers, applied in looſe contexture the one above the other, eaſily to be ſeparated into leaves, which are termed *liber*, and frequently filled with liquid conveyed to them by the extremities of the medullary prolongations, which ſpread themſelves out upon them. The interior layers of the *liber* become, every year, an external layer of wood; this, the wood, a contexture of common veſſels, proper veſſels, tracheæ, utricular tiſſue, preſents a medullary centre, prolongations proceeding from thence, and ſpreading out under the epidermis, annual layers of ligneous texture, which indicate the years of its growth; the interior of which, being the hardeſt, form the heart, and the exterior the ſofteſt, called the ſap.

C. The leaves covered with the epidermis, which is common to all parts of the vegetable, conſiſt of a great quantity of common veſſels, the diviſions of which form a very numerous areolæ, filled up with flat webs of utricular texture, into which a thick juice, frequently viſcous and gluey, is poured out. The veſſels which are tranſmitted into it by the petiole, in which they are ſqueezed together, diverge and ſeparate into diviſions perceptible to the eye in fibrous lines, and ſpread out in the plane ſurface of this part. The leaves may be very well diſſected by maceration in water; they are alſo diſſected by the inſects, which eat the bark and parenchyma, ſo as to leave only the vaſcular texture inſulated. They are perforated at their upper and under ſurface, with a great number of pores, which exhale or inhale vapours or elaſtic fluids.

D. In the flowers, the calixes are abſolutely of the ſame texture as the external parts of the bark, or as the epidermis; they are in fact formed of the epidermis ſpread out, and ſometimes ſwelled. The corollæ are a continuation of the liber, and contain alſo an immenſe quantity of tracheæ, ſo that they may be conſidered as a kind of pulmonary organ in vegetables. The ſtamens are continuous with the interior woody texture, and the proper veſſels; the antheræ are ſmall membranous purſes, folded double, entirely perforated with pores through which a matter exſudes in ſmall drops, which afterwards dries and becomes the pollen, the fecundating powder. The piſtil, a continuation of the utricular or medullary texture, has been compared with the female organs of generation in animals; the ſtigma holding the place of the vulva, the ſtyle of the vagina, and the ovary of the uterus. The vegetable eggs, or the ſeeds, are intirely formed in theſe organs, in which they exiſt previous to fecundation. From this ſtructure of the flower it reſults that it may be conſidered as the ultimate production of the different orders of internal veſſels, as their laſt ſhoot, as a ſpecies of dilatation or ſeparation of the different internal organs; they are the admirable product of the exceſs of nouriſhment and motion in the different orders of veſſels which conſtitute the internal texture of the plant.

E. The fruits are almoſt always formed in their interior part of a pulpy, fleſhy, gelatinous, flabby parenchyma, which conſiſts almoſt entirely of utricular texture, and through which only ſome common veſſels tranſmitted by the peduncule paſs: theſe veſſels, which generally paſs into the centre of the fruits, carry nouriſhment to the ſeeds, and produce, by the effuſion of the ligneous juice, the ſhell which frequently ſurrounds the kernels. Sometimes this ſuperabundant ligneous juice depoſits itſelf in the parenchyma, forming concretions which are often improperly termed ſtones.

F. The ſeeds alſo are formed by the utricular texture, in the veſicles of which a pulverulent, or mucous, or dry and feculent matter is depoſited, which communicates immediately by a kind of umbilical cord with the plantula, which it furniſhes with the firſt nouriſhment, in order to effect the development which takes place in germination. It cannot be doubted that the juice depoſited in this organ is the moſt elaborated, the moſt perfect, and the moſt precious product of the nutrition of the vegetables, as it gives birth to the moſt uſeful part, deſtined to maintain and multiply the ſpecies in ſimilar individuals, which ſucceed each other without interruption.

ARTICLE III.

Of the Phenomena of Vegetable Life.

1. As vegetables differ ſingularly from the minerals or foſſils in their aſpect, their appearance, their external and internal ſtructure, this difference is found ſtill more prominent and decided, when we conſider the play of the organs of which they are conſtituted. Vegetables have already been ſaid to differ from minerals, in their being nouriſhed or increaſed by intuſſuſception, whilſt foſſils increaſe merely by the approximation and external addition of ſimilar molecules. However, this general enunciation is not ſufficient accurately to eſtabliſh the differences which exiſt between theſe two claſſes of bodies.

2. It is from the ſame action of the parts, from the functions that are exerciſed by the different veſſels of vegetables, that we are to derive a more

preciſe notion of their differences from the inorganic laminæ of minerals. The aggregate of the phenomena which take place in the organiſm of vegetables conſtitutes a particular life. Vegetables are juſtly ſaid to live; for we ſee their birth, development, and growth; their exiſtence, and the phaſes of this vegetable life divided into ſeveral ſtages, which ſucceed each other, and each of which preſent different ſcenes dependent the one upon the other; we ſee them ceaſe to grow at a certain period, become fit for generation when they have acquired their full growth, remain for a longer or ſhorter time more or leſs healthy, and vigorous in their adult date; give birth to a numerous progeny, afterwards droop, become enfeebled, deteriorated, even fall ſick, ſubjected to the inevitable lot of whatever poſſeſſes life, and at length arrive as the final termination of their exiſtence, or death.

3. All theſe tranſitions, all theſe periods of vegetable life, which remove them far from the foſſil compounds and approach them to the animals, are effected by an internal proceſs, by ſucceſſive changes which take place in the cavities of the different orders of the veſſels which conſtitute their texture; and theſe changes are executed by means of regular and conſtant motions, which are called vegetable functions. It is not our preſent object to determine either the cauſes or the particular reſults of theſe functions. Our preſent object is merely to aſcertain their exiſtence,

ence, to announce its ſigns or phenomena, in order that we may be enabled to eſtabliſh, in a certain manner, the difference between vegetables and animals.

4. Obſervation alone is ſufficient to ſhow that there takes place in vegetables,

a. An abſorption of the liquids and fluids placed around them.

b. A motion of fluids from one part to another.

c. A modification of theſe abſorbed liquids and fluids.

d. A ſeparation of theſe liquids into different cavities, and into different natures.

e. A development of the organs or progreſſive growth.

f. An ejection of a portion of theſe bodies ſuperfluous for nutrition.

g. A motion in ſome of their ſolids.

h. A ſolidification, or a formation of ſolid, which becomes ligneous ſubſtance.

i. A re-production of the individual.

We muſt caſt a glance upon each of theſe phenomena.

5. The abſorption of liquids and fluids by the pores of vegetables is a phenomenon equally certain and eaſy to be appreciated. The tubes of the roots, and the pores of the leaves, are the principal organs of this abſorption: this is proved by the immerſion of thoſe parts into coloured liquids, and the paſſage of theſe liquids into the veſſels of the plant. In this conſiſts

what is termed intuſ-ſuſception. It is by this means that vegetables imbibe their nouriſhment, that the manures increaſe their growth or change their quality, and that ſoils influence all their properties.

6. Theſe abſorbed liquids form the ſap, which in the ſpring diſtends the common veſſels; and even, when it is very abundant, the tracheæ, the proper veſſels and the utricles; it appears to move from the root or the bottom of the plant upwards into the ſtalks and branches; ſome authors believe that it deſcends again under the bark, and that thus a real circulation takes place. It is proved by means of ligatures, by the ſwellings which they occaſion, by the exſudations and lachrymations which it produces, the inflation of the bark. All the other proper liquids are diffuſed by degrees into their particular veſſels, effuſed into cavities or reſervoirs, and thus tranſported from one place to another.

7. In proportion as the liquids abſorbed are moved in the canals of plants, and circulate in them, they become modified, their nature is changed, they become the different peculiar juices, and acquire properties which render them capable of fulfilling the different uſes for which they are deſtined. In this manner are formed all the different materials of veſſels which we ſhall ſoon examine. Theſe modifications are ſo many chemical products or effects, which can be appreciated when the nature of theſe materials ſhall

have been explained, and compared with that of the nutritive ſubſtances which they abſorb, and which paſs into their tubes. This ſecond ſeries of phenomena anſwers to digeſtion.

8. In proportion as theſe modifications take place, and as the homogeneous liquid, known by the name of ſap, is converted into different proper juices which are to become the ſeveral materials of the vegetables, theſe juices are rejected or ſeparated from the general maſs of ſap, carried by particular channels into various reſervoirs; and this phenomenon has the greateſt analogy with what is called ſecretion in animals.

9. From theſe firſt effects, the abſorption, the motion, the ſucceſſive change, and the regular ſecretion of the vegetable liquids, follows the development, the evolution of the organs which contain them, and thence the growth, the elongation, and the augmentation of volume which they experience. This is a nutrition exactly ſimilar to that of animals. In it we ſee the liquids become thickened, aſſume a conſiderable conſiſtence, become coagulated, changed actually into ſolids, and thus add, as far as a certain term, that of the expanſion which the fibres are capable of aſſuming, to the layers of the trees. It is by this effect that the diſtended bark cracks, is ſeparated, and becomes unequal, rugged, furrowed, &c.

10. This development, this growth of the fibres and the layers which employs the thick-

ened liquids, does not abſorb them intirely. All the matter taken as nouriſhment by the vegetables, and derived from the ſoil, the air, the manures, the water, does not remain intirely in their body. The uſeleſs or ſuperfluous part is evacuated either in the form of liquids which run out by external orifices, or of elaſtic fluids which eſcape by tranſpiration. We ſhall ſee the nature of both hereafter. Theſe excretions, which are ſufficiently proved by a multitude of facts are alſo perfectly analogous with what takes place in animals.

Simple obſervation proves alſo, that at different periods of the vegetable life, and even for the exerciſe of the functions which they perform, ſeveral of their parts execute motions which have ſome relation with thoſe which we obſerve in animals. Thus the petioles of the leaves bend, fold themſelves, approach nearer to or remove to a greater diſtance from the ſtalks and the branches; thus the motion of contortion or flexure is almoſt general in the leaves which follow the courſe of the ſun, and of which the inferior ſide is always turned towards the ground, whilſt the ſuperior is always directed towards the ſky and the light; thus the herbaceous ſtalks incline themſelves imperceptibly towards illuminated places. This phenomenon, which approaches to the nature of animal irritability and galvaniſm, is ſo ſenſible and ſo decided in ſome plants, that they fold themſelves at the approach of all irritating ſubſtances,

ſtances, and almoſt at every kind of contact, as we ſee in the Senſitive Plant: other parts, and eſpecially the filaments of the ſtamina, preſent it in a ſtill more diſtinctly marked manner, and incline themſelves almoſt ſuddenly towards the piſtil when we irritate them with pointed ſubſtances, as we obſerve in the helianthus rue, the barberry buſh, &c. Modern botaniſts have paid much attention to this motion of vegetable irritability; and the more the facts relative to this point in Natural Philoſophy ſhall be multiplied, the more this phenomenon will be generalized.

12. The conſtant term of nutrition and growth in vegetables is the ſolidity which theſe beings acquire in the ligneous ſtate at which they arrive: thus the production of the wood, and the converſion of all their parts into ligneous ſubſtance, reſemble here that oſſification which in the ſame manner terminates the life of animals. Every thing proves that the ſubſtances by which plants are nouriſhed are carried in the ſtate of liquids into their ſtrainers, and that they at laſt become ſolid, loſe their ſolvent, and aſſume the concrete form Our preſent object is only to eſtabliſh the exiſtence and the generality of the phenomena, not to explain them. Accordingly, I muſt confine myſelf to the enunciation of what happens, without endeavouring to aſcertain the cauſes which ſhall be explained after having ſtudied the nature and the compoſition of the vegetable ſubſtances.

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13. One of the moſt incomprehenſible and moſt beautiful phenomena in vegetable life is their re-production. The duſt of the ſtamens, received upon the ſtigma, fecundates the ſeeds contained in the ovary. This is proved by taking away the ſtamens or the antherefe, which leaves the plant barren: it is proved alſo by the hiſtory of the female flowers of the monoecial plants, which do not bear any fruit, unleſs there are ſome male individuals in their reach, by the manner even in which they are fecundated by ſhaking the powder of the ſtamens upon their piſtils; finally, it is proved by the varieties which the ſeeds of trees yield, when fecundated by the ſtamens of other vegetables. The ſeeds pre-exiſt in the ovaries, and the pollen only produces in them the vital motion, or the diſpoſition to contract it. Without this fecundating powder, the ſeeds wither and dry away within their coverings. Scarcely has it touched them, or penetrated them with the vapour which exhales from it (for we do not ſee the whole pollen paſs intire into the ovary), when this diſtends, grows, becomes the fruit, and the ſeed which it contains has become fruitful. After this, when buried in the earth, or penetrated with moiſture, it ſwells, the radicle becomes elongated, and deſcends into the ground; the plumula, equally elongated, elevates itſelf into the air, carrying with it the colyledons which preſent the two firſt leaves, or the firſt leaf, which on that account are termed

ſeminal leaves. When once it has ſprung forth into the air and taken root in the ground, the young plant lives by its own ſtrength; nouriſhed at firſt by its own ſubſtance of periſperma, which forms a kind of milk, the embryo is developed, unfolded, quits this nutrient integument, and draws in its nouriſhment by its own abſorbent pores.

14. To this ſeries of phenomena, eaſy to be diſtinguiſhed, and which conſtitute the vital functions of vegetables, we muſt add the property which plants poſſeſs, of being re-produced or propagated by ſlips, of uniting by their divided barks, of entering the one into the other, of being multiplied by ſuckers, of being varied and married one with another by grafting: we muſt alſo add that germination, foliation, floration, and fructification, divide their life into diſtinct periods; that every year the moſt of them repoſe during the winter, ſleep during the cold, and begin again to live in the warm ſeaſon; and we ſhall have in this delineation, however feebly it may be ſketched, a collection of facts which will leave no doubt with reſpect to the extreme difference which exiſts between theſe beings really organized, and the brute and inorganic matters that have been treated of in all the preceding ſections. It will eaſily be conceived that the chemical properties of theſe bodies muſt be very different from thoſe of the foſſils, and that the manner of appreciating them

muſt be no leſs different from that which has been applied to thoſe. This is the only truth which I have hitherto endeavoured to prove; and I ſhall finally confirm it by conſidering, in a laſt article of this firſt order, the general uſes which vegetables fulfil in the economy of nature, and by comparing them with thoſe to which minerals are deſtined.

Article IV.

Of the Uſes or Functions of Vegetables in the Economy of Nature.

1. WHEN we employ ourſelves with inveſtigating the rank which vegetables hold amongſt the productions of nature, and the uſes for which they are deſtined, we diſcover, eſpecially in this inveſtigation, the moſt prominent difference between the minerals and theſe organized beings. Elevated above the ſurface of the globe, covering its nakedneſs, enriching its dryneſs, and ſubſtituting, inſtead of its aridity, the image of freſhneſs and abundance, the vegetables ſeem to conceal from the eyes of man the foſſils which the earth contains in its boſom, and to invite them to enjoyments which the minerals cannot procure him. Their maſſes ſhooting up into the air in the form of trees, or preſſing upon the ground which they adorn with a brilliant clothing of verdure, preſent

equally, in all points of the globe, the moſt beautiful, the moſt gay, the moſt delightful of ſpectacles, and no animated being is inſenſible to this rich veſture of the earth.

2. The force with which it vegetates, grows, and augments in all dimenſions, when it meets with no obſtacle, when the hand of man does not deſtroy or ſtop it in its courſe, tends to overcharge the ſurface of the earth with ligneous ſubſtance; and if we except the height of mountains above 3000 metres in the atmoſphere, which ſhows the ſtony ſkeleton of the globe, always bare and always naked, the whole cruſt of our planet would be intirely covered with trees and wood. We ſee this in the places where men have not yet fixed their abode; impenetrable foreſts, maſſes of wood in cloſe proximity with each other, occupy the whole ſpace, and reign unmoleſted in it.

3. Thoſe among theſe organic beings which, by the laws which every thing obeys, and after having fulfilled the limits of duration which nature accords to their exiſtence, have periſhed, fall upon the ground, are ſlowly decompoſed, and converted into a nutritious *detritus,* into an earth or ſoil of new formation, which forming layers ſucceſſively applied over the primitive beds of foſſils, gradually raiſe this ſoil, change the proportions of its principles, and conſtitute a maſs of natural manure in which the ſeeds vegetate with rapidity. Thus even, from the ſucceſſive death and decompoſition of the one,

the others derive the ſource of their life and their ſtrength, in order in their turn to furniſh an aliment to the vegetable generation which is to ſucceed them: an admirable uninterrupted circle of the regenerating power which watches over the preſervation of all the productions of nature.

4. Theſe immenſe maſſes of vegetables which ſurmount the foſſils, and reign over them, detain at the ſame time, at the ſurface, the water, that firſt ſource of vegetable fertility, prevent or diminiſh its evaporation, abſorb it from all parts, appropriate it to themſelves, drink it by all their pores, produce the ſame effect upon the clouds or water in the ſtate of vapour, attract them, condenſe them, open myriads of greedy mouths to imbibe them, and frequently retard or annihilate the dangers of heavy rains or ſtorms for the towns which theſe clouds threaten to deſtroy. Thus it has been obſerved, that foreſts inconſiderately hewn down in the vicinity of ſome towns have rendered them infinitely more ſubject to atmoſpheric torrents or abundant rains.

5. The vegetables, by the intermixture of their roots, and the adheſion which they contract with the earth which ſurrounds them, ſuſtain the moſt moveable and leaſt tenacious parts of the ſoil, the ſhrinking of which they retard or intirely prevent; they even defend the ſoil from the undermining action of the water. Human induſtry has availed itſelf of this pro-

perty, in order to give ſolidity to places moſt liable to be undermined or to ſink, whether in conſequence of the want of cohesion in the earth that covers them, or on account of the declivity of the layers upon which this earth reſts, eſpecially when they are attacked by the motion of the water.

6. Whilſt they preſent to man the moſt magnificent ſpectacles, vegetables are deſtined by nature to renovate, by the aid even of their vital motions, the purity and primitive compoſition of the air neceſſary for the ſupport of the life of animals. When acted upon by the rays of the ſun, they pour into the atmoſphere a vivifying ſtream of oxigen gas, in proportion as they vegetate.

7. The vegetables afford at the ſame time a defence againſt the heat of the ſun, a ſalutary and refreſhing ſhade to animals. Under their leafy vault animated beings find repoſe, coolneſs, and ſhelter againſt the winds, rains, and ſtorms; from them they at the ſame time derive their nouriſhment: this is the moſt important purpoſe which plants are deſtined to fulfil in nature. Accordingly, under the denſe ſhades of vegetables, accumulated together upon inhabited regions, and even in the very boſom of the humid ſlime, or the ſtagnating waters which their maſſes ſupport, dwell immenſe nations of reptiles, ſerpents, aquatic birds, inſects, and worms.

8: All the facts that have been collected relative to the economy of nature prove, that no animal can ſupport its exiſtence upon the foſſile ſubſtances, and that without vegetables there would be no animals. It is in theſe organized bodies that all the claſſes of animals find their primitive nouriſhment: for thoſe that live upon other animals devour ſuch as nouriſh themſelves with vegetables. Thus every living body comprehended in the numerous claſs of animal beings derives its firſt exiſtence from the plants; thus the vegetables are deſtined by nature to prepare the primitive aliment of animals, and no ſubſtance can be digeſted by theſe, unleſs it has been previouſly prepared by the interior organs of plants. Conſidered in this extenſive point of view the vegetables are a kind of beings neceſſarily intermediate between the foſſils and the animals; they receive primitively from the firſt the elements of brute and inorganic matter, which they combine in a complex manner, in order to furniſh it to the ſecond, in which it is then ſuſceptible of being converted into their own ſubſtance. They are deſtined to prepare the aliment of animals; accordingly, the number and the weight of theſe correſpond very exactly with the number and weight of the former. Were there only this difference between the foſſils and the vegetables, it would be ſufficient to diſtinguiſh them in ſuch a manner that they could never be confounded.

9. To theſe great uſes in the economy of nature, human induſtry, and the perfectibility of which man is ſuſceptible, have joined an immenſe number for his neceſſities and pleaſures. Without attempting the ſlighteſt ſketch in this place of the arts which are exerciſed upon vegetables or vegetable matter, a ſubject which will be treated in moſt of the articles of this ſection, it will be ſufficient to obſerve that men find in theſe beings, a great variety of foods together with the moſt commodious matter for building their habitations, that of their clothing, the remedies for the diſeaſes to which they are ſubject, even the means of tranſporting themſelves over the waves, the materials of almoſt all the machines which they conſtruct and employ, eſpecially for moving, raiſing, and drawing heavy burthens. They have been able to collect about them uſeful plants of all kinds, to multiply them, to increaſe their production by culture, to perfect and modify their properties in a thouſand ways, to give them dimenſions, odours, taſtes, colours which not originally belonged to them, and to appropriate them in general to their wants and even their caprices.

Second Order of Facts relative to the Vegetable Compounds.

Of the Nature or Chemical Compoſition of thoſe Beings in general.

ARTICLE I.

Concerning the Succeſſion of Labours and Diſcoveries relative to this Compoſition.

1. IT is impoſſible to avoid concluding, from the facts which have been collected in the preceding order, that the vegetable organization muſt form compounds extremely different from thoſe which conſtitute the foſſils, and that the chemical phenomena which theſe compounds preſent muſt alſo be entirely different from the reſults which we obtain in treating mineral ſubſtances. Hence in the firſt labours which chemiſts have beſtowed upon the vegetable ſubſtances, they obtained facts oppoſite in ſome meaſure to thoſe which they had occaſion to obſerve in the foſſils. All the phenomena of the analyſes were then ſo much confounded and mingled with each other in their experiments upon theſe organized bodies, that it required much time and great progreſſion, in the general theory of the ſcience, before they were able to conceive the general cauſe of this difference, in the complication even of the effects, combined by the analytic action to which they ſubjected them.

2. One of the firſt and moſt aſtoniſhing data which they collected in their rude aſſays upon the vegetable ſubſtances, was the impoſſibility which they found of reſtoring to theſe ſubſtances, when once altered by chemical operations, the original compoſition and nature which they had before. Whilſt the mineral compounds, when analyzed with care, afforded them principles which, when re-united or combined in the proportions indicated by this analyſis, formed again the compounds with all their properties, they were unable to obtain any thing ſimilar by their experiments upon the vegetable compounds; and they remained a long time ignorant what was the reaſon of this phenomenon; ſo that they muſt have deſpaired of ever arriving at an exact notion of the compoſition of thoſe beings which thus preſented them, prior to the pneumatic doctrine, only an inſoluble problem, an inexplicable enigma.

3. Accordingly, the whole of vegetable chemiſtry was ſtill confined in 1784, to the extraction and purification of the different immediate products of plants, to the determining their relative ſolvents, to the ſearch for the means of ſeparating them exactly, the ſeizing the principal characters which diſtinguiſhed each of theſe products, in order rather to make them ſubſervient to our wants, than exactly to appreciate their nature. Confined during more than an age to the laboratories of pharmacy, or the workſhops of the arts, this part of chemiſtry was oc-

cupied only with the preparation of medicines, and the production of the different ſubſtances uſeful to men for their numerous wants. If at this period we had ſought philoſophical ideas concerning the nature of vegetables in the analyſis which the chemiſts made of them, we ſhould have found nothing but errors or hypotheſes: and if we had expunged from the treatiſes of chemiſtry what related to pharmacology or the manufactures, nothing would have been left for chemical philoſophy.

4. After the ſimple and often mechanical means of extraction of the principal materials of vegetables, given by the firſt chemiſts, with the ſpecial intention of forming uſeful medicines from them, there was firſt adopted, in order to inveſtigate the nature of theſe materials, and alſo that of the entire vegetables, the violent action of fire, by diſtillation in the retort; and it was ſo firmly believed, that the principles ſo obtained, had exiſted ready formed in them, and were only ſeparated by the heat, that no other method of explaining their virtues was uſed, than that of attributing them to theſe principles. This we particularly remark in the works of Lemery, Geoffroy, and all the authors of the materia medica, from the end of the ſeventeenth till nearly the middle of the eighteenth century. The Academy of Sciences at Paris, even believed that one of the moſt important and moſt neceſſary labours to which they ought to devote themſelves, was the ana-

lyſis of plants by fire; and nearly thirty ſucceſſive years were employed in the execution of this enterprize, recorded and deſcribed with great care in three large folio MS. volumes, preſerved in the library of the Inſtitutes, the fruit of the labours of a Boulduc, a Dodart, a Geoffroy, a Bourdelin, &c.

5. At laſt this method of analyſis was perceived to be fallacious, and that by following this route one was led aſide from the path of truth, for corn and hemlock afforded products almoſt ſimilar to each other. The chemiſts were then for ſome time totally diſcouraged, until, always tormented by the almoſt excluſive wiſh to extract valuable medicines from vegetables, they adopted a new courſe, that of re-agents. They began to treat vegetables and their materials with cold and hot water, and with alcohol, to compare the different effects of theſe two liquors. Boulduc, Hermann, and Cartheuſer, drew ſome uſeful reſults from this method. They calculated the different proportions of the aqueous and reſinous extracts ſeparated by this means. La Garaie taught the art of extracting the ſoluble materials by means of cold water applied to the vegetables in a ſtate of minute diviſion, with the aid of motion communicated by agitators, and of obtaining from them unaltered principles. The books of pharmacology, and of the materia medica, treated then of the virtues of plants, according to this new mode of analyſis;

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4. After the ſimple and often mechanical means of extraction of the principal materials of vegetables, given by the firſt chemiſts, with the ſpecial intention of forming uſeful medicines from them, there was firſt adopted, in order to inveſtigate the nature of theſe materials, and alſo that of the entire vegetables, the violent action of fire, by diſtillation in the retort; and it was ſo firmly believed, that the principles ſo obtained, had exiſted ready formed in them, and were only ſeparated by the heat, that no other method of explaining their virtues was uſed, than that of attributing them to theſe principles. This we particularly remark in the works of Lemery, Geoffroy, and all the authors of the materia medica, from the end of the ſeventeenth till nearly the middle of the eighteenth century. The Academy of Sciences at Paris, even believed that one of the moſt important and moſt neceſſary labours to which they ought to devote themſelves, was the ana-

lyſis of plants by fire; and nearly thirty ſucceſſive years were employed in the execution of this enterprize, recorded and deſcribed with great care in three large folio MS. volumes, preſerved in the library of the Inſtitutes, the fruit of the labours of a Boulduc, a Dodart, a Geoffroy; a Bourdelin, &c.

5. At laſt this method of analyſis was perceived to be fallacious, and that by following this route one was led aſide from the path of truth, for corn and hemlock afforded products almoſt ſimilar to each other. The chemiſts were then for ſome time totally diſcouraged, until, always tormented by the almoſt excluſive wiſh to extract valuable medicines from vegetables, they adopted a new courſe, that of re-agents. They began to treat vegetables and their materials with cold and hot water, and with alcohol, to compare the different effects of theſe two liquors. Boulduc, Hermann, and Cartheuſer, drew ſome uſeful reſults from this method. They calculated the different proportions of the aqueous and reſinous extracts ſeparated by this means. La Garaie taught the art of extracting the ſoluble materials by means of cold water applied to the vegetables in a ſtate of minute diviſion, with the aid of motion communicated by agitators, and of obtaining from them unaltered principles. The books of pharmacology, and of the materia medica, treated then of the virtues of plants, according to this new mode of analyſis;

and the firſt error, proceeding from the altering action of the fire, being ſucceſſively corrected by leſs erroneous reſults, gradually diſappeared.

6. A little after the middle of the eighteenth century, Baccari, in Italy, and Keſſel-Meyer, in Germany, found in the application of cold water, a new mode of analyzing the farina of corn, and diſcovered the glutinous matter, the new vegeto-animal principle, a diſcovery which animated the chemiſts with new courage. Rouelle who, in his courſe, had already added much to Boerhaave's beautiful ſcheme of the vegetable analyſis, was the firſt who diſtinguiſhed with more care the immediate materials of vegetables, divided and characterized the different kinds of extracts by better known properties; diſcovered the glutinous matter in the green leaves, compared the gums and the ſugar with the ſtarch; publiſhed in his proceſſes a more complete and eſpecially a more methodical ſketch of vegetable analyſis than had till then been exhibited, and re-animated the hopes of the labourers of chemiſtry. Bucquet, my firſt maſter, whoſe life was too ſhort for the intereſts of ſcience, publiſhed in the year 1773, under the modeſt title of *Introduction à l'étude des corps naturels tirés du règne végétal*, a work of the higheſt value for the order which reigns in it, and the deſcription of the numerous parts relative to the chemiſtry of plants. At this period every thing was diſpoſed for more important diſcoveries.

7. The pneumatic chemiſtry then began to ariſe, when Prieſtley and Chaulnes examined the acid gas, then termed *fixed air*, produced and diſengaged during the vinous fermentation, and convinced themſelves that it was the ſame as that which Black had found in chalk and the alkalis. Already in 1764, Macbride had admitted its preſence in vegetables, in a manner too precipitate indeed, but ingenious, and calculated to give an uſeful impulſe to the minds of men, and had attributed the putrid decompoſition to its diſengagement; accordingly to him, nothing more was required than to prevent this diſengagement, or to reſtore this principle to vegetables, in order to prevent or correct their ſeptic alteration. Though this firſt introduction of the pneumatic chemiſtry into the analyſis of vegetables, from 1764 to 1784, gave riſe only to falſe notions, it was, however, of ſervice to the ſcience by the diſcoveries, inſulated and incoherent indeed, which it produced. The epocha of the diſcovery of the nature of water, followed ſoon by that of the nature of fixed air, which was found to be carbonic acid, was a flaſh of light for vegetable analyſis. Lavoiſier, by examining the products of the combuſtion of oil and of alcohol; by obtaining more water than their own weight amongſt theſe products, as well as a remarkable quantity of carbonic acid gas; by ſtudying with equal care the phenomena of vinous fermentation, opened a new path, and threw a great light upon the vegeta-

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ble compoſition; explained the nature and the ſource of the products which till then had been extracted by means of fire, why they could not be contained in the vegetables previous to this action, how they were formed. Thus the firſt accurate notion of the organic compounds preſented itſelf. Since this illuſtrious period the ſteps of the chemiſts, which halted before, have become ſteady; the ſcience has proceeded from diſcovery to diſcovery. There has particularly reſulted from it an ingenious and uſeful compariſon between the different means of analyſis till then employed, that by fire, by combuſtion, by diſtillation, by fermentation. Hence alſo aroſe the ſimple idea of vegetable compoſition, which will be traced in one of the ſubſequent articles. My deſign here is merely to preſent in a ſingle point of view, and under a ſingle feature, the reſult of Lavoiſier's labours upon vegetables.

8. All the diſcoveries relative to vegetable analyſis, which have been made either ſome years before 1784, or ſince, may be referred to the new ideas diffuſed by Lavoiſier, of which they are only approximations and neceſſary conſequences. It is in this order that we ought to place thoſe of Bergman and of Scheele, eſpecially of the latter, who has done more towards the improvement of this analyſis, than all the chemiſts collectively had done from the commencement of their labours. Prior to theſe, ſcarcely two or three vegetable acids different

from each other were known. In 1776, Bergman diſcovered the converſion of ſugar into a particular acid by means of the nitric acid, and Scheele ſoon found that this acid was the ſame as that of ſorrel; and from this firſt ſource of the artificial fabrication of a vegetable acid have proceeded many other ſimilar diſcoveries. The laſt mentioned chemiſt ſucceſſively diſcovered the particular exiſtence of the citric, the malic, the gallic, the ſacchlactic acids, and gave occaſion to the ſucceſſive labours of Crell, Hermſtaedt, Weſtrumb, Koſegarten, and Brugnatelli, relative to the formation, the reſemblance, the difference, and the mutual converſion of the acids; diſcoveries which have furniſhed the French chemiſtry with the opportunity of applying its doctrine in ſo happy a manner, as we ſhall ſoon ſee, to the nature and compoſition of all the vegetable ſubſtances. I do not here ſpeak of many other particular facts which we owe to the ſame Swediſh and German chemiſts, and which I ſhall have occaſion to quote elſewhere.

9. During, or ſhortly after, theſe uſeful diſcoveries of the Swediſh and German chemiſts, Ingenhouſz and Sennebier, examined the elaſtic fluids exhaled from plants, the action of vegetables upon different kinds of gas, their influence upon the air, and that of this fluid, of water, and of light upon the vegetables. Their labours approach in a ſingular manner to the firſt data found by Lavoiſier; and though they had taken routes entirely contrary, they in

ſome meaſure met in the career which they had run, by beginning each at oppoſite extremities. Hence reſults the moſt beautiful conformity that can be found in the hiſtory of the ſciences; and it is from a compariſon of the collective maſs of their labours, that the important application has ſprung which has began to be made of the truths of chemiſtry to the phenomena of vegetation. It is from this period that the happy revolution that has been effected in vegetable phyſics truly dates itſelf; a revolution, the actual ſtate of which I ſhall delineate, after having conſidered all the facts which conſtitute the whole of the analyſis of plants which at preſent exiſt.

10. Citizen Berthollet has, on his part, rendered the moſt important ſervices to vegetable analyſis. His labours upon the oxigenated muriatic acid led him, in examining its action upon the vegetable colouring ſubſtances, to determine its nature, and the diverſities of its colours, to explain their alterations by the air, and to underſtand the remarkable influence of oxigen upon the oils, which it thickens, and cauſes to paſs into the ſtate of butter or wax. By other experiments and reſearches, he has diſcovered the ſlow and ſpontaneous decompoſition of the tartarous and acetous acids, and of their ſalts diſſolved in water, the portion of pot-aſh ready formed, which the firſt contains, the attraction of the colouring matters for alumine, and for the oxide of tin, the decompoſitions of the tartrite

of antimony, and of the ſuper-oxigenated muriate of mercury by the decoctions of Peruvian bark. May I be allowed to rank myſelf amongſt the liſt of chemiſts who have improved the vegetable analyſis, on account of the reſults which I have publiſhed in various particular diſſertations, relative to the different coloration of the extractive matters by different proportions of oxigen; concerning the properties of the extracts deſcribed in my analyſis of the Peruvian bark; concerning the converſion of the ligneous ſubſtance into ſeveral acids by the nitric acid; concerning the ſeparation of elaſtic caoutchouc from the juice of the hevæa expoſed to the air; concerning the reciprocal action of the nitric, ſulphuric, muriatic acids, and the vegetable ſubſtances. I have, moreover, undertaken an extenſive courſe of inquiries upon vegetable analyſis in general, in conjunction with Citizen Vauquelin, of which I ſhall exhibit ſome portions in this work, though theſe inquiries are yet far from being completed. I paſs over in ſilence a great number of other tracts in the hiſtory of vegetable chemiſtry, and the diſcoveries which we owe to M. Prouſt, to Pelletier, to Citizen Chaptal, who has rendered great ſervices to the chemical arts relative to theſe ſubſtances, to Citizens Deyeux and Vauquelin, and to ſeveral other chemiſts, as theſe facts will find their place in moſt of the ſubſequent articles, and as moſt of them do not preſent that generality of reſults which alone can make them be conſidered here as having influenced the progreſs of this part of the ſcience. My intention was here only to announce or exhibit the moſt prominent traits of different epochas of the analyſis of vegetables, thoſe which have really changed the face of the ſcience, and have raiſed it to that degree of elevation at which it has arrived.

ARTICLE II.

Of the different Methods of Vegetable Analyſis, compared with each other.

1. FROM what has been explained, though very ſuccinctly, in the preceding article, it reſults, that at the different periods through which the art of chemiſtry has in ſome meaſure paſſed before it arrived at that period of improvement which it now has attained, the methods of analyſing vegetables muſt have varied, and actually have varied. However, nothing has been loſt in this reſpect; even the faults of the antient methods have been turned to advantage; uſeful inductions have been drawn from them towards the eſtabliſhment of new ones; they have been compared with each other, and this compariſon itſelf has furniſhed new and ſometimes unexpected lights. In proportion as l y rectifying its errors, chemiſtry has created new methods, it has not entirely abandoned the ancient ones; it has reſumed them under a new

point of view, and corrected them; ſo that even the inaccuracies of their reſults have then given place to poſitive data. Theſe methods have therefore mutually checked each other.

2. When we conſider, under one point of view, all that has been done more than a century paſt relative to the analyſis of vegetables, and bring together the different means ſucceſſively employed for inveſtigating the nature of plants, we may refer all the modes of treating them that have been adopted, to eight general methods; namely,

a. The natural mechanical analyſis.
b. The artificial mechanical analyſis.
c. The analyſis by diſtillation.
d. The analyſis by combuſtion.
e. The analyſis by water.
f. The analyſis by the acids and the alkalis.
g. The analyſis by alcohol and the oils.
h. The analyſis by fermentation.

By giving a conciſe notion of the operations and uſes of each of theſe kinds of analyſis, we do not yet attempt to determine with exactneſs the chemical properties of vegetable ſubſtances. This ſubject belongs to the third order of facts, which ſhall be treated of in particular after this; but we only continue to exhibit the means which chemiſts have taken in order to arrive at the knowledge of theſe properties, and acquire an accurate idea of the difference between vegetable and foſſil ſubſtances; in a word, it is only a ſequel, and one of the neceſſary portions of the hiſtorical part which forms the general ſubject of the four articles comprehended in this ſecond order of facts.

3. Though the ſeparation of the different ſubſtances of which vegetables are compoſed, effected by mechanical means, is not really comparable with the means of chemical analyſis, I rank it amongſt the methods of analyzing plants, becauſe it actually ſerves to inſulate the materials of which they are conſtituted. This firſt means I term the *natural mechanical analyſis*, becauſe it is effected by nature, When any proper or particular humour ſwells the veſſels or reſervoirs in which it is contained, and cannot remain longer in them on account of its ſuperabundance, it breaks the membranous walls which contain it; it runs out ſpontaneouſly, and appears on the outſide of the plant in the form of an excretion. Naturaliſts and Chemiſts avail themſelves of this circumſtance, in order to collect and examine the products of theſe excretions as materials of the vegetables which afford them: frequently they even increaſe their abundance, by enlarging the natural orifices through which theſe liquids flow out, or by making artificial orifices. In this manner are obtained the ſap, the gums, the ſaccharine juice, manna, the volatile oils, the reſins, caoutchouc, &c.

4. I conſider as the ſecond method, which I term *artificial mechanical analyſis*, the extraction

tion of the different ſubſtances which are obtained by breaking the cells or the veſſels by various mechanical inſtruments differently diſpoſed, according to the nature and texture of the plants, ſuch as mortars, files, preſſes, mills, &c. It is in this manner that we obtain the juices of plants, the mucilages, the fixed or volatile oils. This method, by which not only the liquids are ſeparated from the ſolids, but alſo the different juices; oily, mucous, extractive, coloured, acid, ſaccharine, &c. and the different parenchymas, lamellated, fibrous, the groſs fecula, or the fine and amylaceous fecula, is one of the firſt that are employed upon vegetables in order to obtain their different conſtituent materials, It poſſeſſes the advantage of not changing the nature, or producing any alteration in the materials, and of affording them ſuch as they are in the vegetables; it is much employed in the arts.

5. The analyſis by diſtillation is, as I have already obſerved, the firſt means which chemiſts have employed; and for a long time it was the only one. The vegetables were firſt diſtilled with a gentle fire on the water-bath, in order to extract the water of vegetation; and treated in boiling water to obtain the volatile oil. They were put into retorts of ſtone-ware or iron, to which a receiver was adapted, in which were condenſed the more or leſs ſaline phlegm, the oil or oils, the volatile ſalt, or the carbonate of ammonia, of thoſe vegetables that afforded

any. Since the new diſcoveries, there has been added to it an apparatus for collecting the elaſtic fluids that are diſengaged at the ſame time with the preceding products; there remains a coal more or leſs denſe or rarefied, retaining or having loſt the form of the firſt vegetable ſubſtance which has been decompoſed. This is a really falſe or complicated analyſis, which gives, as I have already announced, ſubſtances formed by the action of the fire itſelf, which do not exiſt in the vegetable, and are manifeſtly compoſed by the influence of the caloric upon the firſt conſtituent matter of the vegetables. At preſent it is employed only for the purpoſe of comparing and oppoſing its effects with thoſe of the other analytic methods, and deducing from this compariſon of the liquids and ſolids of vegetables, the differences or analogies which theſe may preſent, either in the different ſpecies of plants, or in the different ſubſtances of each plant: alone, it would merit no confidence. Combined with other analyſes, this may afford great lights and very uſeful reſults, as will appear very clearly when we ſhall come to develop the nature of the influence which caloric exerts upon theſe organized beings, and upon the matters of which they are compoſed. The Pneumatic Chemiſtry has particularly ſerved to render this mode of analyſis uſeful.

6. When we burn plants or their products, it is ſufficiently known that all theſe ſubſtances are more or leſs combuſtible. It is not merely

with the intention of obſerving, (which however ought not to be neglected) the mode of their combuſtibility, the form and the nature of their flame, their ſmoke, or their odour,—but particularly in order to determine the quantity of coal which they are capable of yielding, the nature of the coal, denſe or rare, heavy or light, porous or ſolid, eaſy or difficult to be burned, ſaline or not ſaline; to aſcertain by incineration the proportion and the properties of the aſhes which they yield, the quantity and the nature of the aſhes which they contain, eſpecially that of which alkali forms part, as alſo the metals or the metallic oxides which may be concealed in them. This *combuſtion* is performed either in caſt-iron veſſels, in which the action of the fire is moderated by ſmothering it, by which means we obtain coals or aſhes not completely burned, and more or leſs oily, which were formerly termed fixed ſalts, prepared after the manner of Tachenius; or it is performed in the manner in which wood is burned in new furnaces, or on a clean hearth, upon a grate of earth or wrought iron. It is by this proceſs that alkalis are obtained.

7. The *analyſis by means of water*, conſiſts in applying in general this liquid to vegetables, or to the different parts of plants, in order to ſeparate from them whatever ſoluble matter they contain. Under this point of view, all the immediate materials of theſe beings have been divided into two claſſes; the one of ſubſtances

ſoluble in water; the other of inſoluble ſubſtances: endeavours have been made to determine the relative proportion of theſe two kinds of ſubſtances. Water may be employed in five ways upon vegetable ſubſtances. Either they are left to ſoak in this liquid cold, which is termed *maceration*, or *cold infuſion*. In the ſecond, theſe ſubſtances are put, divided, and in the ſtate of a more or leſs fine powder, into large quantities of water, in which they are agitated for a longer or ſhorter time by means of agitators. This was the method of La Garaie, by which he obtained beautiful extracts, which he improperly called *eſſential ſalts*. According to a third proceſs, hot or boiling water is poured upon the vegetables or their products, and ſuffered to cool upon them: this is called *infuſion*. A fourth conſiſts in heating water ſlowly and gently upon theſe bodies, and conſtitutes digeſtion, which draws out more of the matter than infuſion, and extracts even more than maceration, in the method of La Garaie. Laſtly, the fifth method is decoction; that is to ſay, the operation in which water is made to boil upon the vegetable ſubſtance. This laſt ſpecies of action takes away much more matter from the plants than the four firſt; but beſides that, it fuſes and carries away ſeveral without diſſolving them; and alſo tears away others from the ſolid texture, and holds them only for a time ſuſpended; it changes the nature of the vegetable ſubſtances to a certain degree, alters their compoſition, deſtroys the equilibrium of their principles, and does not afford the materials which the boiling water diſſolves, without cauſing them to experience a very remarkable alteration.

8. The analyſis of vegetables *by the acids and the alkalis* does not belong, as was formerly believed, ſolely to the menſtrual analyſis, or the action of the ſimple ſolvents. The acids and the alkalis, at leaſt, unleſs very much diluted with water (for in this caſe they ſcarcely act in any other manner than as ſolvents), produce a very great alteration in the materials of vegetables. When they are ſtrong and concentrated, they ſuddenly change the equilibrium of the compoſition of theſe materials; they change their nature; and if we ſhould afterwards take theſe materials thus changed for the true principles of vegetables, we ſhould commit the ſame error as was committed by the chemiſts, when they believed that the products of the diſtillation of vegetables exiſted ready formed in them, previous to the action of the fire. Without explaining here how theſe ſingular alterations of the vegetable ſubſtance produced by the acids and the alkalis are effected, which will be examined in detail in the order of facts that will follow the preſent,—it is ſufficient to know that the modern chemiſts have found, from the data of the pneumatic doctrine, the true cauſe of theſe alterations, and that it has led them to a better knowledge of the vegetable

getable compounds, than could have been hoped for prior to the eſtabliſhment of this doctrine. Since this important diſcovery, the action of the acids and of the alkalis is no longer attended with obſcurity, and they have even become one of the moſt valuable and moſt uſeful inſtruments of analyſis that can be employed, in order to determine the vegetable compoſition with accuracy.

9. By applying the oils, alcohol, and ether, three ſubſtances themſelves of vegetable nature, to the analyſis of plants, it has been obſerved, almoſt ſince the commencement of the eighteenth century, that theſe ſubſtances have the property of diſſolving ſome of the materials of vegetables without acting upon the greater part of the reſt, and that they may thus ſerve to ſeparate theſe materials, and to indicate their relative proportion. They are ſometimes employed before the water, ſometimes after the action of this liquid; and according to the products obtained by the one or by the others, the relative quantity of the different principles which conſtitute them is compared. It has been ſeen, in the preceding article, that after having renounced the falſe inductions which they had drawn from the action of the fire, chemiſts had recourſe to that of water and of alcohol; they then conſidered only what each of theſe ſolvents took from the vegetables to be the real principles of the plants; what remained inſoluble both was conſidered as earth, as a *caput mortuum*, and they

committed this ſecond error, becauſe they conſidered the vegetable analyſis only with relation to the art of healing, and becauſe they thought that this inſipid reſiduum was no longer capable of producing any action upon the animal economy. They did not conceive that ſome materials of the vegetables might eſcape the ſucceſſive action of theſe two ſolvents; and this was a ſecond error, which inſinuated itſelf into the reſults which they deduced from their firſt experiments; but theſe errors, which at preſent are well detected, no longer obſcure the ſcience, nor retard its progreſs.

The inductions which the action of theſe three ſpecies of chemical inſtruments affords, are much more exact than they formerly were, ſince their mode of acting has been better appreciated, as ſhall be ſhown in the following order. They are therefore juſtly ranked amongſt the moſt advantageous means of analyſis that can be applied to the knowledge of vegetables.

10. Finally, the eighth and laſt kind of analyſis, which I diſtinguiſh in the chemical examination of vegetables, is the *analyſis by fermentation*; that which nature employs in order gradually to decompoſe theſe organic bodies, when being deprived of life they no longer belong to the claſs of beings that are uſeful to her views, nor maintain their rank in the order of her economy. The chemiſts have drawn this means of analyſis from the very boſom of nature, and they have nothing more to do in

order to employ it for their purpoſes, than to encompaſs as it were the vegetable ſubſtances with circumſtances and conditions which give riſe to fermentation. It is by the play of the multiplied attractions between the different primitive principles of plants, that the motion of fermentation is produced; the equilibrium of their compoſition is broken; their arrangement, their intimate diſpoſition, change more or leſs rapidly, and thence ariſe new products, the properties of which, when examined with attention, enable chemiſts to conjecture what the ſubſtances were previous to their degeneration: it is, like every other chemical change, an equation of which ſome parts have done nothing more than change their place, and paſſed from one member to another, and which affords, when well underſtood, a more or leſs ſatisfactory ſolution of the problem which we wiſh to reſolve.

ARTICLE III.

Of the general Reſults of the different Analyſes with reſpect to the Vegetable Compoſition.

1. AMONGST the eight diſtinct ſpecies of analyſis which I have enumerated and deſcribed in the preceding article, we muſt admit an eſſential diſtinction, an important diviſion into

two genera; the one in fact conſiſts of immediate analyſes, which ſerve to extract from vegetables the different compound ſubſtances which form their texture, without altering them or changing their nature; they afford, as products, what have been termed immediate or proximate principles of plants, the entire materials which are found ready formed and contained in their veſſels and their reſervoirs, ſuch as their juices, their ſaps, their mucilages, their oils, their fecula, &c. Diſſection, pounding, preſſure, are eſpecially the means of this analyſis. A ſlow fire, the application of water, of the oils, without the aid of a ſtrong or long-continued heat, anſwer the ſame purpoſes; they ſeparate the compounded materials of the vegetables to which they are applied; and by thus inſulating theſe different materials, they give, as their firſt reſult, the number and the relative proportion of theſe firſt component parts, which are themſelves compounded; ſo that they may already ſerve to ſhow the great difference which ſubſiſts between them and the foſſils.

2. This however is nothing more than a firſt point of the vegetable analyſis, and is far from being what chemiſts either could or ought to have contented themſelves with. After having ſeparated and obtained the immediate materials of the vegetables, they ſoon diſcovered that theſe materials themſelves are compounds much more complicated than thoſe which are found in minerals; and the means which they have ſuc-

ceſſively put in practice, in order to inveſtigate the compoſition of theſe immediate materials, belong to the ſecond genus of analyſes, the difference of which I ſhall proceed to ſhow. Theſe analyſes, no longer like the firſt, ſimple extractions, mere inſulations of the materials of which vegetables are immediately formed, they attack more or leſs profoundly theſe materials themſelves in their intimate compoſition: of this order are the more or leſs ardent action of fire, that of water aided by heat of combuſtion, of the acids, of the alkalis, and fermentation; whence it follows, that amongſt the eight ſpecies of analyſes there are ſome which can never be any other than immediate, or not altering [illegible] lyſes, ſuch as the mechanical act of expreſſio others may either be the means of imm extraction, when they are employed with deration or little energy, as fire, wate acids, &c. Laſtly, ſeveral of them never act c wiſe than as altering and decompoſing m ſuch as the action of the concentrated and erful acids, combuſtion, fermentation.

3. It was by obſerving the effects of theſe deſtructive means, of this ſecond ſpecies of analyſis, and eſpecially the decompoſing power of fire, to which, for ſo great a length of time, they had almoſt excluſively recourſe, that chemiſts had conceived ideas, undoubtedly inaccurate and even erroneous, relative to the conſtituent principles of vegetables, but nevertheleſs ſuch as they were then able to conceive. Their inaccurate inſtruments,

ments, and the profound ignorance in which they ſtill were, of the nature of the ſubſtances ſuſceptible of aſſuming the gaſeous form, all of which they took for air, had led them to imagine that vegetables were compoſed of fire, air, water, and earth, and theſe in fact were what they obtained, or believed they obtained, as the laſt reſult of the analyſis of vegetables. The gaſeous carbonic acid and hidrogen gas paſſed at that time for air; they neither knew how to collect them, nor how to determine their differences from the air ſtrictly ſo called; they ſuffered them to eſcape through the tubes and the open extremities of the apparatuſes; y were ſo many products which they ne cted, or which they confounded with th d of the atmoſphere, in which they ſuffered m to be diſſipated. The liquids which they ained, the water which formed their general e, appeared to them to be entirely contained he vegetable matters; they were ignorant t this was a compound which might be formed in a direct way by the torture to which they ſubjected theſe ſubſtances, and that its elements, ſeparated from their ſtate of water, might exiſt merely as particular principles in the plants. The coal which they obſerved appeared to them to be earth, and they had no idea either of the indeſtructible nature of carbon, or of its properties, or of its exiſtence as a principle in organic bodies. Long did this opinion of the primitive compoſition of vegetables

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getables by fire, air, water, and earth, reign in the ſchools, and it received the happy modification at which it has ſince arrived, only by the ſeries of diſcoveries, and of luminous ideas that have followed the eſtabliſhment of the pneumatic doctrine:

4. By means of theſe diſcoveries, modern chemiſts have found that the laſt term of vegetable decompoſition is almoſt always water and carbonic acid; that in order to obtain theſe laſt products of the analyſis of plants, nothing more is neceſſary than to deſtroy the equilibrium which kept their principles united; that all the oxigenated bodies, or thoſe capable of yielding oxigen, by adding that which was wanting, in order ſeparately to ſaturate the carbon and the hidrogen, contribute eſpecially to effect this total decompoſition; and that thus hidrogen, carbon, and oxigen, were found to be the conſtituent principles of vegetables. The union of theſe three primitive bodies preſents in the ternary compounds a ſpecies of mixed combuſtible in part ſaturated with oxigen: theſe are a kind of oxides with binary radicals, in which the three principles which reciprocally ſaturate each other, are united by attractive forces which balance each other in ſuch a manner as to keep up amongſt themſelves the equilibrium and repoſe, which conſtitute the eſſence or the intimate nature of the vegetable compounds.

5. The difference of proportion between theſe

three principles cauſes theſe organic compounds to vary and differ from each other, and thence ariſes the diverſity of what are called the immediate materials of vegetables, the mucilages, the acids, the oils, &c. but the attractions which keep theſe three ſimple bodies united with each other, are capable of experiencing great and frequent alterations, of diminiſhing and augmenting in ſuch a manner, that the equilibrium which approaches them together is eaſily broken: accordingly, theſe compounds, more complicated than thoſe which are found in general in minerals, admitting between their principles, which are more numerous, and at the ſame time leſs approaching to each other, a greater number, and conſequently a greater variability of attractions, are much leſs permanent, and much more ſubject to changes, than what are found in the foſſils. Fire, which ſeparates the molecules of bodies, and diminiſhes their attraction; water, which penetrates and tends to ſeparate them; fermentation, which equally tends to inſulate them; all that can influence this complex compoſition, the equilibrium of which is ſo eaſily deſtroyed, quickly diſſolves the link which keeps the principles in union with each other, varies their nature, modifies them inceſſantly, but always at laſt converts them into the two binary compounds, water and carbonic acid, which are conſtantly the laſt reſults of all the chemical operations to which we ſubject vegetables.

6. Thus we may conceive the multiplied changes which the vegetable compounds undergo between the two extreme terms of alteration which are produced in them by the different modes of analyſis to which they are ſubjected. From the moment when any agent, applied to a vegetable ſubſtance, begins to deſtroy the equilibrium of the attracting forces which exiſt between their three general conſtituent principles, the hidrogen, the carbon, and the oxigen, to that period at which this agent diſſolves them entirely, by uniting both the combuſtibles with the oxigen in particular, till it is reduced entirely into water and carbonic acid, the vegetable matter paſſes through a great number of intermediate degrees of compoſition, in which the carbon is more or leſs inſulated or diminiſhed; the hidrogen becomes equally either predominant or diminiſhed; the oxigen is detached with a portion of the hidrogen, or even of the carbon, or united in a fixed ſtate in a larger proportion than before with this ſubſtance. We alſo ſee it become coloured, ſoftened, fuſed, ſwelled, change its taſte, its ſolubility, become oleaginous or acid; in a word, it aſſumes a great number of modifications dependent upon the change of proportion and of equilibrium amongſt its firſt principles.

7. We muſt therefore conſider in general the vegetable ſubſtances as compounds, at leaſt triple, of carbon, hidrogen, and oxigen; as a kind of oxides, which vary from each other as they paſs out of the hand of Nature, in the

primitive proportion of their principles; very ſubject to alteration in this proportion itſelf, which, by this change of equilibrium, afford in the different ſtates which they are capable of aſſuming, important inductions to the chemiſt relative to their compoſition; which frequently permit us to appreciate more eſpecially this relative proportion between the different materials, which are compared with each other, upon which art operates, whether by diminiſhing or by augmenting this proportion of certain principles, ſo as to modify them, and cauſe them to paſs from one ſtate to another, and thus to ſeize in ſome meaſure, through theſe tranſitions, the modifications of the compoſition of the ſubſtances which experience it. Here I have only to announce the generality of theſe principles; the details and the facts in ſome meaſure ſpecific, which are deducible from them, will be exhibited in the articles of the ſubſequent orders.

8. It is to the ſame conſideration concerning the general nature of the vegetable compounds, that we have to refer the impoſſibility which chemiſts have hitherto found, of forming in a direct way a ſubſtance analogous to that which the plants afford. We have ſeen in ſome of the preceding ſections, and eſpecially in the ſecond, that it is poſſible to unite ſulphur, phoſphorus, and carbon with hidrogen; that this latter combination exiſts particularly in carbonated hidrogen gas, and in the vegetable coals; but when we attempt to add to this binary combuſtible the

oxigen which would be neceſſary, in order to make it approach to a vegetable compound, either the union is not poſſible, or in proportion as it is effected, the carbon and the hidrogen ſeparate the one from the other, and combine ſeparately with the oxigen; and if we reflect for a moment, we find that all the phenomena of vegetable analyſis conſiſt in this. The art of chemiſtry is permitted to inſulate, and to deſtroy the union of the principles in a vegetable compound. As ſoon as it acts upon this compound, it firſt deſtroys its equilibrium; and however ſlight its action may be, it tends to change the nature of its compoſition, to convert it into another, to modify it by entirely deſtroying a portion of it: but it can never augment a vegetable ſubſtance, at the ſame time leaving it ſuch as it is; its means, its inſtruments are too violent, too penetrating, too active; and to nature alone is reſerved the power of creating, reproducing, in a direct way forming the firſt elements or primitive matters of the vegetable compounds. This laſt ſubject, which is of great importance, will be ſufficiently developed in the ſubſequent article.

ARTICLE IV.

Of the Reſults of Vegetable Analyſis in general, applicable to the natural Formation of the Materials of Vegetables during their Life, and to their Alteration after their Death.

1. SINCE all the moſt exact analyſes have ſhown that the vegetable ſubſtances are formed, in their firſt principles, of carbon, hidrogen, and oxigen, to which are added, but only in ſome caſes, and not as indiſpenſable acceſſaries, azote, ſulphur, phoſphorus, &c. it is very evident that the problem of the natural formation of theſe compounds conſiſts in knowing whence the vegetables derive theſe primitive ſubſtances, and how they appropriate them to themſelves, and thus combine them three and three. This problem in fact compriſes the whole of vegetable phyſics; and it is not in theſe firſt conſiderations with which I am here occupied in the articles that form a ſort of introduction, or preliminary diſcourſe, to the analyſis of plants, that I can, or even ought to diſcuſs it in its full extent. I here intend only to point out that intimate relation which ſubſiſts between the generalities even of the knowledge we have relative to the vegetable analyſis, and the facts

which appertain to vegetation: this is the only object to which I can now attend.

2. What I have ſaid above concerning the impracticability of compoſing a vegetable ſubſtance by chemical means, as yet, though we are not denied the hope of being hereafter able to do it, and though the ſame has perhaps already been done without our being aware of it, eſpecially with reſpect to mucilage, the moſt ſimple perhaps of the materials produced by the organized bodies,—what I have ſaid neceſſarily refers to the creative or plaſtic power which vegetables enjoy during their life. The very act of vegetation conſiſts in forming for their own development, for the extenſion and the nutrition of their parts, the different immediate materials which conſtitute them. After having drawn in by their roots and by their pores, which are always open, caloric, air, water, carbonic acid, carbon itſelf in a ſtate of diviſion, which is furniſhed to them by the ſoil charged with natural or artificial manures; the vaſcular, and eſpecially the utricular organs, which every where form their texture, appropriate to themſelves theſe nutritive principles, recompound them, and effect with them, by a ſucceſſion of chemical phenomena or forces, the ternary combination, or compoſitions, which conſtitute their liquids and their ſolids, or their immediate materials.

3. It is ſufficient in this place, if we well underſtand that the formation of the vegetable com-

pounds is the product of the chemical attractions, which exert themſelves in the organic inſtruments of the plants; and conſider whatever takes place in vegetation, in the chemical vegetable conſtitution, as a ſeries of operations, of natural analyſes and ſyntheſes, the determination of which, though eaſy to be conceived in general when the nature of theſe organic compounds is underſtood, muſt depend immediately upon the proceſſes we have deſcribed in explaining the nature of theſe ſame compounds. No doubt can remain reſpecting the influence which the chemical analyſis of vegetables muſt have in the appreciation of the phenomena of vegetable life; and when we ſhall have informed ourſelves in detail with all the properties of thoſe beings, we ſhall ſee what great ſervices chemiſtry has already rendered, and eſpecially how many are ſtill to be expected, from the application of the modern or pneumatic chemiſtry to the philoſophy of plants.

4. The expoſition of the general nature of vegetable compounds is no leſs important for underſtanding that of the different and numerous alterations which they are capable of experiencing after their death. In general, the totality of theſe alterations is to be conſidered as the neceſſary conſequence of their complicated compoſition, and of the play of the multiplied attractions which re-act between the different conſtituent and primitive principles which form them by their union. This equilibrium,

librium, which keeps their elements united, is ſo eaſily diſturbed, and this perturbation is ordained in ſuch a manner by nature, it enters ſo immediately into the plan of her economy, that it is the courſe which ſhe cauſes the vegetable ſubſtances to take, in order to make them reſtore in ſome meaſure the portion of matter which ſhe had lent for their organization, and return it to the common receptacle of its perpetual circulation and employment. This character of deſtructibility depending, as I have ſhown, upon the nature of their compoſition itſelf, is one of the greateſt differences that can be eſtabliſhed between the vegetable matters and the foſſil ſubſtances. The latter always remain in the ſame ſtate, at leaſt as far as relate to themſelves, and are alterable only by external cauſes and accidents; whilſt the former contain in themſelves, and by reaſon of the complicated attractions of their multiplied component parts, an intimate principle of alteration, and of ſpontaneous deſtruction, dependent upon their order of compoſition, which prevents their remaining for a long time in the ſame ſtate.

5. The ſame general data, relative to the compoſition of the primary materials, alſo diffuſe the greateſt light over the arts which are occupied with theſe matters. It has been ſeen that all the ſpecies of vegetable analyſis may be conſidered as belonging to two genera; the one in fact does nothing more than extract, without altering,

tering, the immediate materials of vegetables; the others modify, change, alter, and decompoſe them more or leſs powerfully, either at the very moment in which they are extracted from the plants, or a longer or ſhorter time after they have been extracted. The arts which are exerciſed upon vegetable ſubſtances, if we except thoſe which only change their form or external dimenſion, have equally the double object, either of ſeparating ſome particular matters from vegetables, in order to obtain them inſulated and more or leſs pure, or to convert theſe matters into new products, modified and appropriated to the different uſes of ſociety. Now in both caſes, they are referrible either to ſimple extraction, or to the more or leſs advanced decompoſition of the immediate materials of the vegetables. This general view is ſufficient for the preſent, to ſhow the relation which ſubſiſts between the chemical knowledge that has been acquired reſpecting plants, and the arts whoſe object it is to employ them for the benefit and proſperity of men united in the ſtate of ſociety. The articles compriſed in the ſubſequent orders will give much more perſpicuity and fulneſs to theſe firſt notions.

Third Order of Facts relative to the Vegetable Compounds.

Of the Chemical and Characteriſtic Properties of Vegetable Subſtances in general.

ARTICLE I.

General Obſervations concerning theſe Properties.

1. THE details which I have given in the preceding order relate only to the compoſition of the vegetable ſubſtances in general. They ſhow in what this compoſition conſiſts; they exhibit the notions that have been adopted, and the facts that have been aſcertained by the lateſt diſcoveries of ſcience relative to the nature of the vegetable compounds. After they have been well conſidered and underſtood, they muſt naturally lead us to the inveſtigation of the chemical properties which characterize theſe compounds, the expoſition of which they render more eaſy, and their theory more luminous.

2. I call thoſe the chemical properties of vegetable compounds, which, ſhown in the manner in which thoſe compounds, when deprived of their life, or ſeparated from the living vegetable are affected by the different re-agents, to the contact of which they are expoſed, the changes they

experience, and the new reſults which they afford. It muſt undoubtedly be here expected that great differences will be found between the organic matters, and the mineral or foſſil ſubſtances. In general the firſt, being more complicated in their compoſition, are infinitely more changeable by the action of theſe bodies, and the alterations which take place in them muſt be more multiplied, more difficult to be underſtood or well explained, than thoſe that have been indicated in the hiſtory of all the preceding ſubſtances.

3. As this new part of the ſcience has not yet been treated and developed in a ſufficiently extenſive manner in moſt of the works of chemiſtry, and as in general the vegetable analyſis has not yet received, in the elementary books, that extenſion of which it is ſuſceptible, and which alone is capable of affording an adequate notion of its preſent ſtate, as well as of accelerating its progreſs, I have thought it incumbent upon me to treat of the properties of vegetable compounds in general, before ſpeaking of their immediate materials in particular. By this means the hiſtory of the latter will become much more perſpicuous, and will require no additional details, which would occaſion a great number of repetitions.

4. Amongſt the alterations which conſtitute the effects of the different agents upon the vegetable compounds, and which determine the chemical properties of the latter, though they all

tend to their decompoſition, and at laſt even produce it completely, there are ſeveral which are only a kind of converſion of the one of theſe matters into the other; and this is one of the characters moſt intimately connected with their nature. Conſidering them all under this point of view, we ſhould be led to ſay, that there is only one ſingle vegetable ſubſtance in general, ſuſceptible of a number of modifications, of ſucceſſive tranſitions from its firſt ſtate, or moſt ſimple compoſition, to its complete decompoſition. Thus we are induced to believe that mucilage is the firſt vegetable compound, that which is the leaſt remote from the foſſils by its ſimplicity, and that the acetous acid is in this genus the laſt term of the compoſition; ſo that, when we ſhall well underſtand the ſucceſſive alterations or modifications which the vegetable matter is capable of undergoing, we ſhall be able to arrange in a natural order all the immediate materials of vegetables, which are really nothing more than co-ordinate and neceſſary tranſitions of the vegetable compound from one ſtate to another, and of which it is neceſſary only to determine accurately the relations and natural arrangement.

5. Under this head of remarkable permutations, it is that we ought to arrange all the changes of which the vegetable ſubſtances are ſuſceptible, or all the chemical properties which characterize them, and are only the different effects of thoſe changes. Hence it happens,

that however different the agents or the inſtruments may be which muſt be employed in order to determine theſe properties, they all reſemble each other in their ultimate or more energetic action; or at leaſt there ſubſiſts between them, in the mode of their effects, relations, or analogies, which I ſhall not neglect to point out. Thus all the re-agents proper for changing the nature of vegetable ſubſtances modify them at firſt, cauſe them to aſſume different ſtates, which ſeparate them into different compounds leſs complicated than they were at firſt, and all equally conclude with reducing them, as the laſt reſult, into water and carbonic acid.

6. But though this analogy, ſo illuſtrative of the effects of the re-agents, is connected with the very eſſence of the vegetable compound, though I obſerve that I here conſider the whole maſs of the materials of vegetables only as a ſingle compound, as a kind of matter produced by the work of vegetation, I am obliged, in order to enunciate all the modifications which this ſubſtance is capable of experiencing from the different agents, and which conſtitute its real chemical properties, to diſtinguiſh theſe into as many particular effects as there are agents or inſtruments capable of enabling us well to determine theſe properties. This method will have the advantage of ſuffering nothing of importance to eſcape, and of preſenting the regular ſeries of all the modifications which the vegetable matter can and actually does aſſume.

I diſtinguiſh all the chemical properties of the vegetable ſubſtance in general, conſidered here as a ſingle genus of compounds, into ſeven phenomena, according to the number of agents which exert their energy upon this matter. Theſe ſeven phenomena ſhall have the titles of actions of fire, of air, of water, of the alkalis, of the acids, of the ſalts, and of the oxides and metallic ſolutions. By conſidering the whole in ſucceſſion, we ſhall not only aſcertain the degree of perfection which the ſcience has already acquired, but alſo the elevation to which it may ſtill hope to arrive, and the perfection which it ought to attain.

ARTICLE II.

Of the Chemical Properties of Vegetable Subſtances treated by Caloric.

1. BEFORE I here determine with preciſion what are the chemical changes which caloric produces in the vegetable compound in general, I muſt diſtinguiſh thoſe which it cauſes it to to undergo, according to the different proportions of its accumulation, or according to the degrees of temperature. Four phenomena preſent themſelves here, and ought to be ſucceſſively examined; the one is inſpiſſation or deſiccation; the other anſwers to what is termed diſtillation on the water bath; the third is coction

tion or baking; the fourth the total diſſolution of the principles, whether in cloſe or in open veſſels. The three firſt are only partial decompoſitions ſimple changes, or modifications; the laſt is the complete decompoſition.

2. No one is ignorant, that however mild the temperature may be, and however moderate or ſlight the quantity of heat which is accumulated in a vegetable ſubſtance, whether liquid or ſolid, its nature is gradually changed, indeed in a longer or ſhorter ſpace of time, and in a more or leſs feeble degree. Thus, by the heat of a ſtove, the vegetable liquids are thickened, their colour grows deeper, they aſſume viſcidity, conſiſtence, and even a perfectly ſolid ſtate. Thus the juices become concrete and coloured; as that of the heads of poppies forms opium; from the white and very liquid ſtate in which it formerly was, it becomes reddiſh-brown and ſolid. The ſame happens with the juice of aloes and of euphorbium. It is not, however, as has been believed, the mere evaporation of the water which produces this effect; and it is not a ſimple inſpiſſation which takes place even without the contact of the air. Some of the principles have already re-acted upon each other; already has the equilibrium of the vegetable compoſition undergone ſome derangements, and a ſmall portion of the hidrogen having eſcaped with the water, the matter is a little more carbonated, and conſequently a little more coloured than it was before.

3. The ſolid and freſh parts of vegetables, when we wiſh to dry them, to deprive them of the water of their green ſtate, which would produce an alteration in them, and to preſerve them afterwards without alteration in this ſtate of dryneſs, undergo ſomething ſimilar, whether we leave their deſiccation to be effected by the rays of the ſun in a convenient ſeaſon and weather, or effect it by the artificial heat of ſtoves. The following are the changes that take place in the delicate texture of the flowers, the more ſolid texture of the leaves, the ſtill more ſolid ſubſtance of the bark, the ſtalks or the roots. Their colour changes, or if it be preſerved in the moſt permanent, it becomes deeper, and is ſenſibly altered; their organization is deſtroyed; in proportion as their water is diſſipated, a more or leſs perceptible odorous matter eſcapes from them in ſtreams that are inviſible, but very diſcoverable; animals avoid or ſeek it, according to its nature; and the air is frequently altered by it. If the deſiccation be too violent or too long continued, the vegetable matter not only becomes inodorous, brown or yellow, dry and brittle, and frequently little or not at all ſapid, but after examining it, we find it almoſt burned, and very much altered; ſometimes even it is no longer fit for the purpoſes for which it was deſtined.

4. Diſtillation on the water bath produces a change very different from that which has hitherto been attributed to it: undoubtedly it diſen-

gages the water that exiſts ready formed in the vegetables, and reduces it to the ſtate of vapour; but it is not only this water contained and exiſting ready formed which is raiſed, but a certain portion is alſo formed by the tendency which the hidrogen has to inſulate itſelf with the oxigen. The carbon, which ſoon predominates, gives a fallow or light-brown colour to the vegetable ſubſtance. It is true that the gentle temperature, which this mode of treatment produces, affords only a very ſmall quantity of this product; but this is ſufficient to induce a ſenſible change in the organic matter, which, after it has experienced it, is no longer exactly the ſame as it was before. Together with this water, partly contained, and partly formed by the diſtillation on the water bath, an odorous matter is ſublimed, which was long conſidered at a particular vegetable principle, and deſignated by the names of *ſpiritus rector* or *aroma;* but I have proved by particular inveſtigations, of which I ſhall give an account in the article concerning vegetable tranſpiration, that there exiſts no aromatic principle properly ſo called; that every ſubſtance, whatever it may be, has a determinate odour when it is volatilized; that whatever eſcapes in vapour from the ſubſtances which are ſubjected to the action of the fire, preſents itſelf with this odorous character; that it is moſt frequently volatile oil, diſſolved in water, which conſtitutes it, but that it may alſo be a ſmall quantity of extractive matter, mucilage, or ſome gaſeous ſubſtance.

5. I have diſtinguiſhed, as a particular phenomenon or product of fire, the coction or baking of vegetables, as the chemiſts have not yet paid ſufficient attention to this ſingular change, which however is one of the moſt known and moſt uſeful to mankind. It is known that when we expoſe to a dry heat continued for a longer or ſhorter ſpace of time, either immediately upon the fire of the grate, or in the hot aſhes, a vegetable ſubſtance, ſolid and generally a little ſucculent, a pulpy, parenchymatous fruit, a ſtalk, or a tuberous root; theſe ſubſtances, penetrated with caloric, grow tender, ſoft, more eaſy to be bruiſed than they were before, acquire a mild and ſometimes ſaccharine taſte, inſtead of the inſipid or even auſtere flavour which they had at firſt, and are afterwards much more agreeable, as an aliment, to man, and even to ſeveral animals, whilſt at the ſame time they become more eaſy of digeſtion. Is it not therefore evident, even to one who has leaſt ſtudied this part of natural philoſophy, that a remarkable change muſt take place in the vegetable ſubſtance thus baked and become pulpy, ſoft, and ſweet; that there has been formed in it water and ſaccharine matter by a new combination of its principles, and that coction is one of thoſe tranſitions of compoſition which approach greatly to the nature of maturation or of germination?

As to the roaſting of ſome other dry vegetable ſubſtances, an operation which is alſo ſometimes called baking, ſuch as that of the farinaceous grains, cheſnuts, farina, fecula, bread, it is very evident that the reddiſh colour, the brittle property, and the ſomewhat acrid taſte which theſe ſubſtances acquire, are the product of a more profound and more violent alteration which they undergo, and which in ſome meaſure reſembles what takes place at the commencement of deſtructive diſtillation with the naked fire of which I am about to ſpeak. The roaſting of coffee is the firſt term of alteration which a dry vegetable matter can undergo, previous to its total decompoſition, in the economical operations to which vegetables in common uſe are ſubjected.

6. When we expoſe a dry vegetable ſubſtance to a heat above that of boiling water, in cloſe veſſels, in an apparatus compoſed of a retort of ſtone-ware, of iron, or of hard glaſs, and coated with lute in order that it may be able to reſiſt the action of the fire, a receiver of glaſs, provided with a tube of ſafety, and terminated by a tube immerſed under a glaſs jar filled with water; and if we apply to this apparatus a graduated heat till the bottom of the retort has become red hot; the vegetable matter will be then entirely decompoſed, by its inſulated principles acting upon one another; we obtain a ſucceſſion of gaſeous, liquid or even ſolid products, which did not exiſt in the ſubſtance, and there re-

mains a coal retaining the primitive form, and even organization, if the ſubſtance was ſolid, or more voluminous and differently configurated if the matter was fuſible. Though theſe products differ more or leſs from each other, accord- to the diverſity of the vegetable ſubſtances which furniſh them, and though it is neceſſary well to diſtinguiſh the products of the gums, for example, from thoſe of the oils, the extracts, the woods, as I ſhall ſhow in the following order of this ſection, there exiſts nevertheleſs, even in the midſt of this diverſity, an identic generality of alteration, which depends upon the nature of vegetable compoſition, and ought to be here conſidered in its aggregate as a characteriſtic property of this genus of compounds. The manner in which the pneumatic doctrine has arrived at the knowledge of the nature and cauſe of this attraction is one of the moſt beautiful reſults of the revolution of chemiſtry, and one of the moſt ingenious theories which at the preſent day we poſſeſs. It explains all that was obſcure and uncertain in the operations of the chemiſts: it ſhows how they were led into error; how the new materials that were obtained were formed; how, even from the formation itſelf of theſe materials, we may derive a ſufficiently exact knowledge of the nature and primitive compoſition of vegetable ſubſtances.

7. In order to comprehend the remarkable changes produced upon vegetable ſubſtances

ſtances by the action of a violent fire, it is neceſſary we ſhould recollect that theſe ſubſtances are compoſed of three primitive principles, hidrogen, carbon, and oxigen, maintaining themſelves in their equilibrium of ternary combination at the ordinary temperature, on account of the equality of attraction which exiſts between them. But when the temperature is raiſed, when the caloric, penetrating the maſs of this compound, removes the molecules farther from each other, then the attraction which keeps them united is weakened, and they tend to ſeparate from one another; and if the heat be but a little ſuperior to that of boiling water, the hidrogen and oxigen ſeparated in part from the carbon combine together and form water, which is diſengaged; a portion of the hidrogen combines with a certain quantity of carbon, and forms an oily compound, which is volatilized: thus the phlegm and the oil, the two firſt products of a vegetable ſubſtance diſtilled by a degree of heat ſuperior to that of boiling water, were not contained ready formed in the ſubſtance, but are to be conſidered as productions of the fire. At the ſame time when theſe two compounds are formed, ſeveral vegetable acids are alſo formed, which likewiſe did not exiſt in the vegetable ſubſtance, but are owing to the combination of a portion of carbon, of hidrogen, and of oxigen in particular proportions; the pyromucous and the pyroligneous acids are the beſt known of theſe empyreumatic acids,

acids; though there is reaſon to believe that there are ſeveral others hitherto unknown, which are compoſed in this manner by the action of the force. In proportion as theſe new combinations are effected at the temperature which I have indicated, carbon is left behind, which not being able to enter into theſe combinations on account of its ſuperabundance with relation to the hidrogen and oxigen, retains ſome of the fixed ſubſtances, eſpecially of the ſalts and earths contained in the ſame organic ſubſtance, abſorbs a portion of oxigen, and forms a coal which remains in the retort.

8. But when we apply to the vegetable ſubſtances a heat much ſuperior to that of boiling water, and ſuch as to render the retort red hot; water is then no longer formed; becauſe at this temperature the carbon having a ſtronger attraction for the oxigen than the hidrogen has, carbonic acid is ſooner produced; and the portion of water which was formed previous to the application of this violent heat is decompoſed during this ſecond period by the red-hot carbon, and forms carbonic acid: the hidrogen being then ſet at liberty is diſengaged, fuſed by the caloric into elaſtic fluid, in the ſtate of carbonated hidrogen gas; oil likewiſe is then no longer formed, and that which had been formed and had remained in the vegetable ſubſtance is decompoſed. This is what happens at the end of the diſtillation of vegetables in the retort, and is the reaſon why

at this period, the temperature being much elevated, a conſiderable ſwelling takes place in ſuch of theſe ſubſtances as are fuſible. The abundant diſengagement of carbonic acid and carbonated hidrogen gas then raiſes the whole maſs, and fills the receivers with a grey ſmoke, on account of the portion of carbon which the latter very hot gas carries with it, and of which it begins to depoſit a portion in the upper part of the apparatus, from the firſt degree of refrigeration which it then experiences. The action of the fire does not ceaſe till there is no longer any hidrogen or oxigen in the ſubſtance ſubjected to diſtillation, and then the coal which is its reſiduum remains alone and without any volatile matter.

9. According to the rapidity and the force of the heat which is employed in this operation, we obtain at pleaſure either the one or the other of the two kinds of phenomena and products, which, in fact, depend upon the difference of temperature with which this diſtillation of a vegetable ſubſtance is effected. The firſt kind of phenomenon is characterized by the formation of water, of oil and of the liquid acids; the ſecond by the diſengagement of carbonic acid gas and carbonated hidrogen gas. We have it in our power to decompoſe or alter the organic matter in either manner, to change it into either of the new compounds: and thus by the diverſity of alteration which is in our power,

it is very well ſhown in what the action of fire upon vegetables really conſiſts.

10. I do not here ſpeak of that product of diſtillation by naked fire, or the violent decompoſition, effected by heat, which is obtained much more rarely and much leſs conſtantly than the preceding, from only ſome vegetable ſubſtances, becauſe it is only a kind of acceſſary of the firſt, and becauſe this product, which is conſtant in the diſtillation of animal ſubſtances, is formed only in the diſtillation of thoſe vegetable ſubſtances, which approach to the nature of the former: this product is ammonia. It is obſerved only in ſuch of theſe ſubſtances as contain azote amongſt their principles, and which, by this addition, become complicated in ſuch a manner, that they have long been termed *vegeto-animal* ſubſtances by the chemiſts; of theſe we ſhall ſpeak in the following ſection:

ARTICLE III.

Of the chemical properties of vegetable ſubſtances treated by the air.

1. IT was impoſſible for chemiſts to comprehend or explain the effects of the air upon the vegetable ſubſtances that are expoſed to it, after having ceaſed to live or vegetate, at the time when they knew neither the conſtitution of the air nor the general compoſition of theſe ſubſtances.

ſtances. Though they were able to obſerve ſome of the alterations which they undergo, eſpecially the moſt prominent and remarkable, they were unable either to aſcertain exactly in what they conſiſted, namely the real changes that had taken place in the compoſition of theſe ſubſtances, or to determine the part which the contact of the air had in them. They ſaw that the vegetable ſubſtances became coloured, dried, and withered, or were decompoſed, when theſe effects were ſufficiently marked to be very manifeſt and diſtinguiſhable; but they neither knew whether the ſame phenomena took place in cloſe veſſels, nor why or how the atmoſphere contributed to their production. Moreover, when we compare the few notions which the Ancient Chemiſts poſſeſſed relative to this ſubject, even concerning the moſt violent of theſe alterations, we ſoon ſee that moſt of the facts which concern them eſcaped their notice, and that it was even very natural that they ſhould hardly pay any attention to them: accordingly, prior to the eſtabliſhment of the pneumatic doctrine, before the data of Lavoiſier and Citizen Berthollet, nothing had been ſaid concerning the properties of the vegetable ſubſtances dependant upon the air. The elementary books, written even ſince that period, have treated too ſuperficially concerning this ſubject.

2. In order that I may omit nothing that belongs to theſe chemical properties derived from the action of the air upon the vegetable

ſubſtances, I ſhall deſcribe them, or rather I ſhall announce them here as forming ſix very diſtinct phenomena.

a. The object of the firſt will be the abſorption of a principle of the air by theſe ſubſtances.

b. That of the ſecond, the precipitation and the concretion in the vegetable liquids which follow this abſorption of one of the principles of the atmoſphere.

c. The third will comprehend the coloration which theſe ſubſtances undergo.

d. The fourth, the kind of combuſtion to which we may refer this chemical property in general.

e. The ſubject of the fifth phenomenon will be the change which the air itſelf experiences from the action of the vegetable ſubſtances, in proportion as its contact cauſes them to experience the four firſt.

f. Laſtly, in the ſixth and laſt phenomenon, I ſhall rank that kind of decompoſition, more or leſs ſlow, which vegetable ſubſtances undergo by the contact of the atmoſpherical air.

This diviſion into ſix phenomena, by particularly fixing the attention of chemiſts upon each ſpecies of alteration which the air produces in the vegetable compounds, will be attended with the particular advantage of omitting nothing which is eſſential to be known reſpecting this genus of chemical properties; and though this department is not ſo far advanced as were to be wiſhed, it will at leaſt appear very proper for exciting the attention of the learned, and engaging them to ſtudy, more than they have done hitherto, this kind of action, which deſerves to occupy them, and form the object of more profound reſearches than thoſe to which it has yet given occaſion.

3. It is a fact well known in the immenſe ſeries of pneumatic experiments which have been made during more than twenty years paſt, that when we expoſe a ſubſtance, and eſpecially a vegetable liquid to the contact of the air, in a veſſel which ſerves exactly to meaſure its volume, and alſo enables us to examine the alteration which the air has experienced, a more or leſs ſenſible abſorption takes place, or diminution of volume more or leſs diſtinguiſhable. When we examine, by eudiometric means, what part of the air has been abſorbed, we find that it is oxigen gas, and that what remains of the air is more or leſs mephitic, more or leſs ſurcharged with azotic gas. Almoſt all the vegetable liquids poſſeſs this property; but it is more remarkable in ſome, ſuch as the ſaps, the juices of herbs, the oils, the extracts diſſolved in water, &c. ſome vegetable liquids effect it even in ſo powerful a manner, that they become very frothy by agitation. We muſt take care not to confound thoſe which become frothy in conſequence of a gas which is diſengaged from them, with thoſe that become covered with a frothy ſcum in conſequence of the abſorption. The

firſt

firſt preſent this phenomenon without the contact of the air; the ſecond produce a vacuum in veſſels partly full, in which theſe liquids are agitated; it is probable even that we may hereafter find ſome vegetable ſubſtances that have a ſufficient avidity for the atmoſpheric oxigen to act endiometrically upon the air.

4. In proportion as the liquid or diſſolved vegetable ſubſtances that are expoſed to the air abſorb oxigen from it, they become turbid, depoſit flakes which are precipitated, or become covered with concrete plates of which they did not previouſly exhibit the ſlighteſt trace. In this manner the oils concrete at their ſurface, or even in their interior part, by the abſorption of the oxigen, as has been diſcovered and well proved by Citizen Berthollet. In this manner, I have diſcovered that the expreſſed and clarified juices, when expoſed for ſome time to the air, become filled with concrete flakes which ſwim in their liquor, and which are depoſited after ſome hours; which does not happen to them in well-dreſſed and full veſſels; there are even ſome decoctions of dry vegetable ſubſtances, of woods, barks, and roots, which become turbid by the contact of the air, and which afterwards depoſit powders, or thick and ropy inſoluble maſſes, or irregular flakes. I have particularly obſerved that much of this matter was formed in the decoctions of Peruvian bark that were made to boil for a long time, and that they thus loſt the greater part of their vir-

tues. It is therefore one of the well characterized chemical properties of vegetable ſubſtances, to be rendered in this manner concrete by the atmoſpherical oxigen which they abſorb, and to form oxigenated products, which precipitate themſelves from the liquids, and which have become inſoluble, or much leſs ſoluble than they were before.

5. The coloration of vegetables by the air is one of the moſt known and moſt conſtant phenomena; every one indeed knows that the white roots of ſalſifis, the white petioles of the Spaniſh thiſtle, beet, the huſks of nuts, the pulp of pippin-fruits, &c. when expoſed for ſome time to the air, aſſume yellow, brown, and even black colours, againſt which, attempts are even made to guard them, in order to preſerve that whiteneſs which is agreeable in alimentary ſubſtances. The colours which ſome kinds of white wines ſo rapidly aſſume in bottles, alſo afford a frequent proof of the exiſtence of this coloration; to this we may add the coloration of the ſkins of fruits, that of the leaves which acquire a deep green colour, of the barks which become brown, of the flowers which do not acquire their tints till after they are blown, and which, having been almoſt colourleſs in the calicine covering in which they were folded up, become adorned with all their colours when they open in the atmoſphere; but theſe phenomena being complicated with thoſe of vegetation, during which they take place, I

ought here to mention thoſe only which belong to vegetable ſubſtances when deprived of life. I have ſtudied with attention, and deſcribed in "Annales de Chimie, tome V," the influence of the atmoſpherical oxigen gas upon the coloration of vegetables, Having been ſtruck with the beautiful blue colour which indigo aſſumes in the air, after having been taken green out of the dyeing-vats, with the blackneſs which ſubſtances impregnated with galls and which ink aſſume in the air, with the brilliant or deep colours which all the cryptogamic plants exhibit when they are altered or decompoſed in the atmoſphere, with all that takes place in calico-printing and dyeing, with reſpect to the uſe which is made of vegetable ſubſtances in thoſe arts, as well as with the phenonomena of coloration which I have juſt quoted in the different parts of living plants, I particularly directed my reſearches to the infuſions and decoctions, and eſpecially thoſe of the barks of the yellow or red woods. I obſerved, that when expoſed to the air, they become covered with a granulated pellicle, which paſſed ſucceſſively through the colours of brown-black, brown-purple, cheſnut-red, orange and yellow; that in the latter ſtate, the coloration by the air was fixed, and becomes little or not at all alterable; that previous to the coloration in yellow or fawn, which is the laſt term, the vegetable matter paſſed through different tinges which remained ſtationary and fixed, according to the different proportions of oxigen. I have proved that theſe ſhades were really owing to the fixation of oxigen, by imitating them by the addition of different proportions of oxigenated muriatic acid to theſe decoctions: I particularly obtained from the decoction of Peruvian bark five or ſix colours more beautiful, more rich, and eſpecially more ſolid than the ordinary lakes, of which I ſhall ſpeak hereafter. From the whole of my labours upon this ſubject, I have drawn the following general reſults: *a.* Oxigen combined with the vegetable ſubſtances changes their colour; *b.* the proportions of this principle produce variations in the ſhades; *c.* theſe ſhades follow a kind of degradation from the deepeſt to the lighteſt colour; *d.* the vegetable reds, purples, violets, cheſnuts, blues, owe their tinges to different proportions of oxigen; *e.* the complete ſaturation with this principle produces the yellow, or the fawn, which is the moſt durable of all the vegetable colours; *f.* the change of colour by the abſorption of the oxigen is followed by a change of nature, and the vegetable ſubſtances which experience it become leſs ſoluble in water, and more or leſs oily or reſinous.

6. Beſides the concretion and coloration which are obſerved in vegetable ſubſtances expoſed to the air, and which are owing to the fixation of a more or leſs conſiderable proportion of atmoſpheric oxigen; theſe ſubſtances undergo a ſlow combuſtion and an alteration in their

compoſition, which has been very well determined by the experiments of Citizen Berthollet. At the low temperatures to which vegetable ſubſtances are expoſed in this kind of experiments, hidrogen has more attraction for the oxigen than carbon has: accordingly, the hidrogen, a principle of theſe ſubſtances, tends to diſengage itſelf from them, and is actually ſeparated, molecule after molecule, in ſuch a manner as to burn by degrees with the atmoſpherical oxigen, and to form water: hence the drops of this liquid, which appear upon the ſides of the receivers, in which we thus expoſe in conſiderable volumes of air the ſliced fruits and the chips of wood, whoſe alterability by the air we wiſh to determine. In proportion as this hidrogen exhales and burns ſlowly in the air, the quantity of carbon, which forms one of their principles, augments and colours the vegetable ſubſtance the more ſenſibly, the more conſiderable this augmentation is. This is the manner in which Citizen Berthollet has explained the brown colour which woods aſſume by their expoſure to the air. This effect is well known in the wood of the oak, and in that of the walnut-tree; it is ſtill more remarkable in mahogany, which from a delicate roſe or pale fleſh-colour paſſes to a blackiſh brown: it is known that this alteration, the product of a ſlow combuſtion of the hidrogen and ſeparation of the carbon, takes place only at the ſurface, ſince whenever we remove or uncover this ſurface, we find a much leſs deep colour, which indeed muſt in its turn aſſume the above-mentioned caſt, when it ſhall have been left for ſome time expoſed to the air.

7. It is alſo of eſſential conſequence, in order to appreciate what happens to vegetable matters during the changes which they experience by the contact of the air, to determine at the ſame time the change which the air itſelf experiences, and this determination muſt equally lead to the knowledge of what happens in theſe ſubſtances, or the real nature of their chemical properties. Air, which has been left for ſome time in contact with the vegetable ſubſtances, is found deprived of a part of its oxigen, which is determined by the eudiometric proceſſes. It even occurs pretty often in the circumſtances of common life, that it is not neceſſary to have recourſe to eudiometrical proceſſes in order to perceive this alteration which air experiences from the action of vegetables. Cloſe places, in which theſe ſubſtances are accumulated, conſtantly become dangerous to animals; perſons have often been known to have been ſtruck with aſphyxia in confined or cloſe places, where a large quantity of flowers, leaves, or ſtalks were drying, or where large heaps of hay or fruit were accumulated. Beſides the odorant matter proceeding from the volatilization of ſome of the principles of the plants, or of their parts, the frequently pernicious alteration of the air ſhows itſelf here under three aſpects, or produced

by three cauſes acting at the ſame time. The one is the abſorption of a portion of its oxigen, of which I have already ſpoken; the other conſiſts in the combuſtion of the hidrogen, which I have developed in the preceding number; and the third, of which I muſt alſo ſpeak a word here, muſt be referred to the formation of a certain quantity of carbonic acid gas. This, the influence and the quantity of which may be determined by the fixed alkalis and lime-water, ſhows that hidrogen is not the only combuſtible principle diſengaged from the vegetable ſubſtances by their expoſure to the air; that whilſt it exhales from theſe ſubſtances it carries with it a ſmall quantity of carbon, which being extremely divided by this aëriform ſolution, burns, either at the ſame time as the hidrogen, or immediately afterwards, as takes place in the lungs of animals. Thus the air, at the laſt term of its alteration by dead vegetable ſubſtances, may be entirely deprived of its oxigen; contain a large proportion of water, the greater part of which, not being able to be held in ſolution, is precipitated; become charged with a portion of the vegetable matter in the ſtate of vapour, which gives it a ſmell more or leſs ſtrong of carbonic acid; preſent even a temperature more elevated than the atmoſphere, by the double condenſation which its oxigen gas experiences, both by uniting with the hidrogen, and by combining with the carbon. Thus theſe different effects, ſo well appreciated by the pneumatic doctrine, throw the greateſt light upon the alterations of vegetable ſubſtances by the air.

8. Every one knows that beſides the five effects, or rather beſides the ſeries of different alterations which I have juſt explained, and which characterize the chemical properties of the vegetable ſubſtances with reſpect to the action which the air exerciſes upon them, or which they exerciſe upon the air, they are at laſt decompoſed more or leſs ſlowly and completely; they undergo a kind of analyſis, which ſeparates from them by degrees all the volatile principles, and collects their fixed elements in the form of an earthy reſidue, or rather one of an earthy appearance; that in this manner, Nature employing the air at once as a reſervoir and an inſtrument, deſtroys, with the aid of time, the moſt ſolid texture of ancient trees, as well as the moſt frail and delicate fabrics of annual plants; that ſhe reſtores to the general circulation of beings the principles which ſhe had lent for ſome time to theſe organized bodies. But as this effect of ſpontaneous analyſis, of natural and ſlow decompoſition, is complicated of the actions of caloric and water with that of the air, as it gives riſe to different and very important reſults that are to be conſidered in particular; and laſtly, as it deſerves to be comprehended and treated more particularly in this ſection, in the order of facts which ſhall follow that devoted to the examination of the immediate materials of

plants, I ſhall here only announce it, in order to render more methodical and more complete this outline of the alterations which vegetable ſubſtances undergo, or the chemical properties which they preſent by the action and the contact of the air. I ſhall reconſider and explain it in a more ample manner, in the fifth order of this ſection, devoted to the examination of the alterations of which the vegetable compounds are ſpontaneouſly ſuſceptible.

ARTICLE IV.

Of the chemical properties of vegetable ſubſtances treated by water.

1. THOUGH I have already conſidered water as a means of analyſis, acting upon vegetable ſubſtances, and ſerving to ſeparate from them ſome of the materials of which they are conſtituted, though I have already remarked that it may be employed as an inſtrument in five different manners, by tranquil maceration, by agitated maceration, by infuſion, by digeſtion, and by decoction, means to which we may alſo add that of diſtillation, I have not yet proceeded to examine with due attention the changes, or the chemical properties which theſe ſubſtances are capable of experiencing from the action of water, but merely the general effect

of this agent and the influence which it may have upon the ſeparation of the principles of plants.

2. In this place another view preſents itſelf, another kind of conſideration, not leſs important and much more profound than that which related to the vegetable analyſis in general. It is neceſſary that we ſhould determine, with preciſion, all the effects which water produces upon the vegetable compounds, the different alterations which it cauſes them to experience, and afterwards the chemical properties which it exhibits in them. By approximating all the phenomena which water, employed in the different proceſſes above indicated, produces in vegetables, by comparing together all the different effects which reſult from thence in their compoſition, I find that they may be reduced to eight, which are very diſtinct, and which muſt be examined in particular, in order to appreciate their relation to the chemical properties of theſe organized bodies.

3. Theſe eight phenomena ſeem to follow each other in the order and according to the diſpoſition which I am about to lay down.

a. Abſorption and ſoftening.

b. Mechanical ſeparation of the parts.

c. The fuſion or inſulation of ſome of the immediate materials.

d. The ſolution of ſome others.

e. The new union or the mixture of ſuch of theſe immediate principles as are diſſolved at the ſame time.

f. The alteration which they undergo either by the action of the water, or by that which they naturally exert upon each other.

g. The coction, or the complicated effect of the boiling of the vegetables in water.

h. Finally, the total decompoſition, which is the termination of the action of the water, and the ultimate term of the chemical properties which the vegetable ſubſtances preſent by its influence.

It is, however, neceſſary to remark that theſe phenomena are not always produced by the action of water upon theſe vegetable ſubſtances; that caloric has more or leſs influence upon them, according to the temperature to which we elevate the water we employ; that ſince, even when we take cold but liquid water, it contains an abundant proportion of this principle, it is evident, that it always enters for ſomething into this action.

4. The firſt effect of water is known to every one, and takes place in every vegetable matter which is impregnated with this liquid, which is kept immerſed in it, or which is even placed in the air when water is precipitated from it; this matter abſorbs it, becomes penetrated with it, admits it from all ſides between its laminæ, its layers, its fibres, or its molecules; theſe are then removed from each other and ſwell; whence reſults an augmentation of volume, a change of form,

an enlargement which are made uſe of in many of the arts, and which, as is well known, anſwer many uſeful purpoſes. This effect is not merely that of ſuction and of the capillary tubes, as has been aſſerted by natural Philoſophers in their mechanical explanations; it would in that caſe have no relation with chemiſtry, and would not deſerve to be enumerated amongſt the properties which this ſcience ought to examine in vegetables. It is not confined to a mere phyſical power; it follows the laws of chemical attractions, and on this account the vegetable ſubſtances differ even in the manner in which they abſorb water, in which they are penetrated by it, in the quantity which they abſorb of it, in the degree of augmentation of volume which they experience from it, and eſpecially in the adheſion which they contract with it. Accordingly, different woods ſteeped in water for the ſame ſpace of time, augment differently in weight and volume, and dry afterwards with different phenomena.

5. When the vegetable ſubſtances have remained for ſome time immerſed in water, thoſe whoſe texture is the moſt delicate, are not only penetrated with the largeſt quantity of this liquid, but experience alſo, by the effect of the removal of their laminæ or fibres from each other, a ſeparation, a kind of diſſection, which detaches filaments from them; ſo that theſe are precipitated or depoſited at the bottom of the liquid, the tranſparency of

which they impair by remaining for ſome time ſuſpended in it. From this action, which alſo depends upon the affinity of the vegetable molecules with thoſe of the water, there reſults a diſorganization of the former, ſoon followed by a more decided alteration, a more intimate decompoſition or change of nature, of which the firſt ſeparation has been the ſource. It is not only in the furfuraceous form or in laminæ, leaves or filaments, that the water thus detaches, by long contact, the different materials of the vegetables; frequently, this ſeparation, which takes place in conſequence of the different attraction of the immediate materials of the plants for the liquid, preſents, as it is effected, ſoft, pulpy, mucous, flaky, gelatinous ſubſtances, which float in the liquid, or which are depoſited in different layers, but this ſeparation is then accompanied with a conſiderable alteration of the ſame materials, and belongs to one of the ſubſequent effects.

6. When we employ water conſiderably heated for treating vegetables, the elevated, and eſpecially the continued temperature aſſiſting the action of the water, cauſes it to penetrate more deeply into the parenchyma and the organic texture of the plants; and this liquid, having become more active, divides, ſoftens, and entirely fuſes ſuch of the immediate materials as are ſuſceptible of this change of ſtate; ſo that without combining with the water, which even repells their union, theſe materials are nevertheleſs,

theleſs, inſulated from the vegetable, and preſent themſelves alone with the properties which characterize them. Thus when we boil roots or barks for a long time in water, we ſee at the ſurface of the liquor drops of oil, which float without mixing with the liquid. Reſin, Gum-reſin, and ſeveral other immediate materials of vegetables are affected in the ſame manner, and the ſeparation of theſe materials contributes to the analyſis of the plants, or of the parts of plants which are ſubjected to it.

7. At the ſame time that theſe three effects of water take place, or after they have taken place, this liquid takes up from the vegetables ſuch of the materials as are ſoluble in it, and accordingly as theſe are more or leſs numerous, or more or leſs abundant, the water takes up a different proportion, and favours the ſeparation or the analyſis of theſe materials: theſe then partake of the liquidity of the water, and cannot be ſeparated from it except by evaporation; and it is always with the ſole and almoſt excluſive intention of thus diſſolving ſome of the immediate materials of plants, that water is employed in their analyſis; but it is neceſſary to add to what I have already ſaid upon this ſubject, that the different ſoluble materials of theſe bodies are ſo in different degrees, and vary according to the more or leſs ſoluble texture to which they belong, according to the age of the plants, and according to the particular ſtate of theſe

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theſe materials. Some of them, and we ſhall ſee that to this claſs belong the mucilages, the extracts, the vegetable ſalts, &c. are very ſoluble in the cold, and in ſmall quantities of water; others require a heat more or leſs intenſe, and alſo a larger quantity of this liquid to diſſolve them; whence it follows, that, according even to the variability of this chemical property in the plants, or the vegetable matters of whatever kind which we examine, we ought to treat them differently with reſpect to the proportion and the temperature of the water which we employ, as a firſt trial will ſufficiently indicate.

8. It is not to the mere loſs of theſe materials ſoluble in water that vegetables are limited, under this point of view, as to their chemical properties indicated by the action of water; there takes place alſo during and by the act itſelf of this ſolution, another effect equally neceſſary and important to be appreciated, in order to acquire a knowledge of theſe properties; when two, and ſtill more ſo when more than two of theſe ſoluble materials paſs thus from the vegetables into the water, this fluid combines and unites them in another order and under another form than than that in which they exiſted in the natural ſubſtance whence it has taken them: ſo that it muſt not be concluded from this experiment when employed as a means of analyſis, that theſe matters, ſo diſſolved and afterwards found again in the water, exiſted in the ſame ſtate, and in

ſome reſpect under the ſame aſſociation in the vegetables that has been analyzed. Thus the ſugar, the gum, and the eſſential ſalt which are found diſſolved at the ſame time in the water, and which adhere to each other, after having been artificially ſeparated from it, were not combined three and three in the ſame manner in the vegetables from which they proceed; and in like manner the materials that have not been touched by the water, but which have eſcaped its ſolvent action whilſt the former were diſſolved in it, are applied and united to each other in a a different manner than they were when they formed integrant parts of the texture and of the parts of plants.

9. The conſequence of this alterative and combinatory action which water exerts upon the vegetable ſubſtances which it diſſolves, as alſo upon thoſe which it leaves undiſſolved when it is brought to act upon plants, is neceſſarily a change of nature, an alteration of ſome kind, eſpecially between the diſſolved ſubſtances which muſt re-act upon each other, and become different from what they were at firſt. This is a reſult which muſt well be kept in mind in the vegetable analyſis, which, without the condition here propoſed, would lead us to commit many errors. I have ſhown in the preceding article, that the air has great influence upon the ſtate of vegetable compounds diſſolved in water, upon the product of the infuſions and the decoctions: there are

therefore here, with reſpect to the chemical properties of the vegetable ſubſtances, three effects, which become complicated by being aſſociated with each other; the one is the action of the water itſelf upon the ſubſtance diſſolved; the ſecond is the combination of ſeveral of theſe ſubſtances diſſolved at the ſame time; and the third is the influence of the air upon this matter held in ſolution; whence it follows that it is not every action of water upon a vegetable that furniſhes exactly and without any alteration, the ſubſtances this liquid takes away from it; and this depends upon the great alterability of theſe ſubſtances, the ſlight equilibrium which keeps their firſt principles combined, and the facility with which it may be broken.

10. A great part of the phenomena which I have juſt enunciated in their generality, are united in the operation ſo familiar to mankind, when they boil plants in water, in order to render their vegetable aliment better taſted, more tender, and more eaſy of digeſtion. It is well known what a great difference there is in the taſte, ſoftneſs, and agreeableneſs in general, between vegetables boiled in water and baked vegetables, of which I have ſpoken in one of the preceding articles. It is known that the change produced by this boiling is owing to the preſence of water which penetrates them, makes them tender, ſoftens them, diſſolves ſome of their principles, changes more or leſs their nature and their properties, converts for example

the harſh juices into mild matter, and the inſipid matter into ſaccharine ſubſtance. It is therefore very evident that this change is owing to an union of the different alterations of which I have ſpoken in the preceding numbers, and that, if we well conceive the nature of theſe alterations, it will not be difficult to comprehend perfectly the boiling of the vegetables in water; an operation the phenomena and the reſult of which chemiſts have not ſufficiently determined. They have not determined, for example, why water, holding a ſmall quantity of earthy ſalts in ſolution does not effect this boiling; which appears to depend upon the circumſtance that the water, being ſaturated with theſe ſalts, and eſpecially with the ſulphate of lime, is no longer able to diſſolve the vegetable matter, which, in this ſoftened ſtate, conſtitutes the boiling of plants. Sufficient attention has not been paid to the very uſeful power of the vapour of water in boiling pulſe, grains, and fruits, which is employed with ſo great advantage, eſpecially with reſpect to hard, raw, and ſaline water, and may ſerve in certain countries or at ſea for this important purpoſe, becauſe the action of the fire reduces only the pure water into vapour which acts upon the vegetable ſubſtances.

11. Water, like caloric and air, has the power of completely decompoſing the vegetable compound, and entirely ſeparating its principles. This is a fact which is proved by a thouſand

circumſtances, and eſpecially by that which is ſo frequently and ſo abundantly exemplified before our eyes in the immerſion of vegetables in this liquid. We ſee at every moment the plants plunged in this liquid become completely deſtroyed in it; they become ſoft, pulpy, and are reduced into a kind of ropy and putrid mucilage, which quickly diſappears. This phenomenon varies in the woods, which firſt become black in it, and afterwards brittle. It is very remarkable in the ſtalks of hemp and flax, which, by remaining too long in the water of the ſteeping-veſſels, or by too long ſteeping, are burned, become black, putrefy and entirely loſe their conſiſtence. In chemical experiments, as well as in the operations of nature, every vegetable ſolution is gradually decompoſed and deſtroyed; but theſe effects are owing to a complication of cauſes and of actions, and alſo preſent a ſeries of important differences or modifications, which it is eſſentially neceſſary to examine in the moſt detailed manner, and which I reſerve for the fifth order of facts relative to the alterations of which vegetables are ſuſceptible. Our preſent object is merely to deſcribe in general the complete decompoſition effected by water, and to explain it as the laſt term of the chemical properties and actions which the vegetable ſubſtance can preſent under the influence of this liquid.

12. It reſults from theſe eight phenomena appertaining to the re-action of water upon vegetable ſubſtances, that moſt of them conſiſt

in a ſeries of actions, which, like thoſe of the air and of fire, tend really to inſulate the conſtituent principles of theſe ſubſtances, to change their nature, to extract them, or to reduce them to the ſtate of two or three binary compounds, or even to their primitive elements; and that this ſeries of actions cauſes the vegetable compound to paſs through ſucceſſive modifications, which frequently reſemble thoſe which it experiences in nature, and even in the veſſels of the living plants; which proves that the general progreſs of this decompoſition is uniform, and obeys conſtant and determinate laws.

ARTICLE V.

Of the Chemical Properties of Vegetable Subſtances treated by the Earths and the Alkalis.

1. IF we except ſome very well-known combinations between the alkalis and certain immediate materials of vegetables, ſuch as thoſe between the oils and thoſe baſes which conſtitute the ſoaps, ſcarcely any thing has hitherto been ſaid concerning the reciprocal action between thoſe two kinds of ſubſtances; and nevertheleſs it is not to be doubted that they have a more

or leſs energetic tendency towards each other. The well-known energy which the cauſtic fixed alkalis exert upon organic ſubſtances in general, is too great and too powerful for it not to be exerciſed in ſome manner upon the vegetable ſubſtances: it is therefore of importance to attempt at leaſt to ſupply, by ſome general conſideration, and by the collection of ſome facts, the almoſt total ſilence of chemiſts with reſpect to this ſubject.

2. The dry earths, ſilex and alumine, produce no very ſenſible alteration upon vegetable ſubſtances: it is well known, that when immerſed in pure and well-dried ſand, they keep without alteration. Beſides the advantageous uſe to which this kind of inhumation is applied, in rural and domeſtic economy, in order to preſerve roots and pulſe without change guarded againſt the moiſture, the atmoſpheric variations, and the proceſs of germination, when the precaution is uſed of placing them in a depth at which the temperature is not ſubject to variation; we alſo know that induſtrious art which preſerves with a kind of freſhneſs, and even with their moſt exact forms and more tender tints, plants of a delicate texture, by ſprinkling and ſurrounding them with fine and dry ſand, in veſſels to the middle of which they are fixed and ſuſpended in their natural ſituation. Thus ſilex has in ſome ſort the power of preſerving the properties, the organization, and the com-

poſition of vegetables; it prevents their alteration and ſpontaneous analyſis; it checks their ſeptic decompoſition.

3. The ſame is not the caſe with alumine: always more or leſs humid, or retaining between its molecules a certain proportion of water, argil does not ſerve in the ſame manner for the preſervation of vegetable ſubſtances; accordingly they become altered, and putrefy when ſurrounded with or buried in it. This kind of alteration, which is conſiderably rapid even with wood buried in the argillaceous earths, is entirely owing to the water which they retain; and it is only becauſe this ſpecies of earth is always moiſt and ſoft, the vegetables experience in it this decompoſition, of which, as we ſee, the alumine is the occaſional cauſe. This earthy baſe unites pretty eaſily with certain vegetable ſubſtances, with the mucilages and the oils; but this effect belongs to the hiſtory of the immediate materials of which I ſhall treat elſewhere.

4. The alkaline and acrid earths, barites, ſtrontian and lime, are very analogous to the alkalis ſtrictly ſo called with reſpect to their action upon vegetable compounds. They powerfully abſorb the water with which they are impregnated; they dry them, and even effect upon them a kind of ſemi-combuſtion, by the heat which they produce in ſeizing the water which is contained in them. There are even ſome of the immediate materials of plants upon which they exert an action of combination, as I ſhall

I ſhall ſhow hereafter. Magneſia, which is frequently preſcribed by the phyſicians, in its mixture with vegetable powders, favours the ſolution and extraction of ſome of their principles; but this action has not yet been examined or determined with ſufficient accuracy to enable me to ſay more concerning it in this place.

5 I ſhall not here ſpeak of the combination ſo well known under the name of ſoap, which takes place between the fixed alkalis and the vegetable oils, nor of the action of theſe baſes upon the colorant parts: this ſubject belongs entirely to the hiſtory of the immediate materials of vegetables, with which it is not yet time for me to occupy myſelf. I ſhall only enunciate ſome generalities relative to the manner in which we may conceive the properties which the vegetable compound preſents, when it is ſubjected to the action of the pure and powerful alkalis, whether in the ſolid or in the liquid form. Theſe baſes, which are ſo energetic and ſo greedy of moiſture, quickly take away that which is contained in the vegetables. But their action is not limited, like that of the acrid earths, to a ſimple deſiccation. When we triturate them dry with the ſubſtances, they effect a profound alteration in their texture, their organization, and their compoſition. They ſoften them, frequently reduce them into a ſoft pulp, colour them, and decompoſe them. The ſame effect takes place, but in a leſs power-

ful degree, with the cauſtic diſſolved alkalis, eſpecially when their ſolution is denſe and concentrated: then, even without the aid of heat, which however greatly augments their activity, they powerfully diſſolve the vegetable ſubſtances, and bring them into a kind of ſaponaceous ſtate. It is in this manner that unſized paper aſſumes the form of pulp, runs quickly into holes or becomes diſſolved, when we employ it to filtrate alkaline leys. It is in the ſame manner that linen, employed for the ſame purpoſe, loſes its ſtrength and part of its weight; an inconvenience which is perceived even in the domeſtic operations of waſhing and bleaching, when too ſtrong leys are employed. There are ſome vegetable ſubſtances, ſuch as approach to the animal ſubſtances by the azote which they contain, which, like the latter, yield ammonia at the moment when they are triturated with ſolid alkalis. This phenomenon I ſhall explain more at length when treating of the immediate materials of vegetables in the ſubſequent orders. The cauſtic alkalis, by the avidity with which they tend to unite with water, effect the decompoſition of ſome vegetable ſubſtances by inſulating their oxigen and their hidrogen. This action reſembles that of the acids.

6. The properties which the vegetable compounds preſent in the action which they are ſuſceptible of experiencing from ammonia, approach but ſlightly to thoſe which I have juſt deſcribed relative to the fixed alkalis: they

have an analogy, which may be eaſily conceived from the comparative nature of theſe ſalifiable baſes. But the weakneſs of this ſpecies of volatile alkali explains how ammonia has only in a few circumſtances even a ſlight ſolvent action upon theſe compounds. It favours, ſtill leſs than pot-aſh and ſoda, the ſolubility of ſome of theſe compounds in water, and it changes their nature but very little.

ARTICLE VI.

Of the Chemical Properties of the Vegetable Subſtances treated by the Acids.

1. THOUGH chemiſts have long employed the acids for the purpoſe of examining vegetable ſubſtances, and though they have obtained ſome advantage from them with reſpect to the knowledge of their properties, it is only ſince the great diſcovery of Bergman, of the converſion of ſugar into a peculiar acid by means of that of nitre, that this kind of vegetable analyſis has become a means of the greateſt importance for appreciating the chemical properties of theſe compounds. The pneumatic doctrine has eſpecially thrown the greateſt light upon this decompoſing action of the acids; this alone has been able accurately to appreciate its exiſtence, to

determine its cauſes, to verify its reſults, and well to diſtinguiſh all its phenomena. It may even be ſaid, that between the diſcoveries of Bergman and Scheele, the two firſt chemiſts who have indicated the change of the vegetable compounds by the nitric acid, and the ingenious explanations founded upon other diſcoveries of the French pneumatic doctrine, the diſtance and the interval for the progreſs of the human underſtanding, is greater than between the ancient ſtate of chemiſtry and the firſt obſervations of the two Swediſh chemiſts. No part of the ſcience has made a more ſtriking progreſs, nor has arrived at more beautiful reſults than this: and though that of the action of the powerful acids upon vegetable ſubſtances has not by any means been carried ſo far as it evidently may hereafter, there is nevertheleſs no re-agent, which has more effectually contributed to the knowledge of the chemical properties of vegetables than theſe active inſtruments.

2. It is difficult to generalize the action of the very decompoſable mineral acids upon vegetable ſubſtances, becauſe this action differs, more or leſs, according to the nature of the acid, and according to that of the organic ſubſtance. It may however be ſaid, that it always tends to deſtroy theſe compounds, to cauſe them to paſs through ſeveral intermediate ſtates previous to their total decompoſition, and that it eſpecially converts them into ſeveral vegetable acids more or leſs energetic, more or leſs oxigenated,

genated, till the period when it changes them completely into water and carbonic acid; by augmenting the quantity of oxigen in general, they frequently ſeparate part of the hidrogen or of the carbon, which they burn ſeparately, and cauſe them to fly off in the form of water and carbonic acid. Thus they change the relative proportion of their firſt principles; they cauſe the nature of the vegetable compoſition to vary in many reſpects: hence the multiplied ſtates of the products, and of the phenomena to which they give riſe.

3. But notwithſtanding this multiplicity of actions and of converſions produced in the vegetable compounds, by the powerful acids with ſimple or with unknown radicals; many which depend upon the ſtrength of the acids, their quantity, and even the differences of the vegetable ſubſtances, and the temperature at which they are treated, we may however refer to three general modes the alterations to which theſe bodies give riſe, or the chemical properties which the vegetable ſubſtances preſent when treated by the acids. Sometimes in fact they are diſſolved without being ſenſibly changed; ſometimes they experience an alteration without the acid itſelf having yielded oxigen, ſometimes their nature is changed, or they are converted into new products, at the ſame time that the decompoſed acid gives them a portion of its acidifying principle. In the latter caſe, the al-

teration of the vegetable ſubſtance is much more profound than it can be in the two firſt circumſtances. It is of importance to conſider each of theſe effects.

4. In order that the powerful acids may act only as ſimple ſolvents of the vegetable ſubſtances, it is neceſſary, either that theſe acids ſhould be very much weakened, or that the vegetable compounds of a greater or leſs degree of denſity ſhould ſtrongly reſiſt their decompoſition. The latter caſe is extremely rare, and in ſome ſort foreign to the vegetable nature: the firſt is that which moſt frequently takes place. There is ſcarcely any vegetable ſubſtance which is not ſuſceptible of being diſſolved, either in the cold or by heat, by all the acids when weakened and completely ſaturated with water; and there is alſo no acid whatever, which has not the property of effecting this ſolution, when it is made without ſenſible decompoſition on a portion of the vegetable ſubſtance; there is no change of colour in this ſubſtance, and no change whatever is diſcovered in the acid. Frequently we may ſeparate the matter thus diſſolved by means of an earth or an alkali, which ſeizes the acid, and forces it to quit the diſſolved matter. It is then depoſited almoſt without alteration, or at leaſt but very ſlightly altered.

5. But though not altered at the moment of its ſolution in a weakened acid, the vegetable ſubſtance does not remain without a more or leſs powerful alteration when this ſolution is

kept. At the end of ſome days we find it no longer poſſeſſed of all its properties; its nature is gradually changed; it is decompoſed, and it paſſes ſlowly with the aid of time into the ſtate which it is ſuſceptible of aſſuming in the caſe where the ſame acid, when ſtronger, attacks its combination quickly and powerfully. This is obſerved conſtantly in thoſe ſolutions when kept for a longer or ſhorter ſpace of time. They are all found changed into vegetable acids.

6. The ſecond caſe of the action of the acids, which I have diſtinguiſhed with reſpect to the different properties of which the vegetable ſubſtances are ſuſceptible when treated by the acids, is that in which they are altered, changed, modified, without the acid itſelf being decompoſed, without its loſing or being ſeparated from its oxigen. The ſecond caſe had not yet been appreciated before Citizen Vauquelin and myſelf gave an account of it towards the end of the fifth year of the Republic. It takes place eſpecially in the action of the ſulphuric acid upon theſe ſubſtancs. When we ſuffer theſe two kinds of ſubſtances to act ſpontaneouſly upon each other, when for example we mix in the cold this acid with ſtraw or wood, &c. the vegetable ſubſtance is diſorganized, ſoftened, and as it were diſſolved; a remarkable quantity of carbon is ſeparated from it, and it is eaſily ſeen that it is decompoſed, as if it had been in part burned or heated in cloſe veſſels. Before the inveſtigations that have been mentioned, it was believed

that the ſulphuric acid produced this effect by the ſeparation of its oxigen. However, as no ſulphureous acid is diſengaged during this remarkable change, and as we find the ſulphuric acid not decompoſed, not diſoxigenated, after it has taken place, it certainly proceeds from another cauſe. This is determined by examining the ſtate of the acid; it is extremely weakened without its nature being changed; it contains a large quantity of water which it did not contain before; when it is mixed with a freſh quantity of water, it does not produce, by far, the ſame heat which it produced previous to this re-action. It is therefore evident that it conſiſts in a formation of water, that the ſulphuric acid, by the great tendency which it has to unite with this liquid, has ſolicited and effected the ſeparation of a portion of the hidrogen and oxigen of the vegetable ſubſtance, and has conſequently ſet its carbon free; that this alteration, of which the acid greedy of water is the occaſional cauſe, without however relinquiſhing its own oxigen, has no limit, except the ſaturation of this acid by the water, and that it conſequently paſſes entire into the vegetable ſubſtance. We ſhall ſee that this is the cauſe of the phenomenon of etherification, or the formation of ether.

7. In proportion as this decompoſition of the vegetable ſubſtance by the concentrated ſulphuric acid takes place, as it is converted into water and carbon, a portion paſſes alſo into the ſtate of acid; it is almoſt always to the acetous

acid that this acidification tends: it may be obtained by diſtillation. We ſhall ſee hereafter that this acid is formed by the union of a given proportion of oxigen of carbon and of hidrogen; and it is evident that it is, like water, the product of a change of equilibrium in the vegetable ſubſtances. It muſt be remarked, that during this particular kind of alteration no efferveſcence takes place; no bubble of elaſtic fluid is ſeparated, as in fact no principle of the vegetable or of the acid is diſengaged. There is only diſengaged a certain proportion of caloric by the union of the acid with the water that is formed, and in proportion to the denſity acquired by this combination, as well as to the precipitation of the carbon.

8. The muriatic acid acts in the ſame manner upon the vegetable compounds when it is concentrated, and when it is left for a long time in contact with them. The muriatic acid gas, as being very greedy of water, acts ſtill better than the liquid and fuming muriatic acid; but the action of both is infinitely longer than that of the ſulphuric acid, on account of the little activity of the muriatic acid. When we ſuffer a vegetable ſubſtance to remain for a long time in contact with this acid, it at laſt becomes colored brown, black, is ſoftened, carbonated, and the acid is found to be extremely weak. As the decompoſition of the muriatic acid has not hitherto been obſerved, ſince we knew of no circumſtance in which it relinquiſhes oxigen, it is eaſy to con-

ceive that all the effects which it produces upon vegetable ſubſtances are occaſioned only by the attractions of the maſs itſelf in all its integrity. Thus when, after long contact of ſome of theſe ſubſtances, which then approach in their nature to that of the animal ſubſtances, with the muriatic acid, we extract muriate of ammonia from the mixture, we muſt conclude that this alkali is formed, like the water, at the expenſe of the principles of the vegetable, and by the attraction which the acid exerciſes upon the ammonia.

9. With reſpect to the phenomena which vegetable ſubſtances preſent with the acids which are decompoſed together with them, they all depend upon the ſeparation of the oxigen from theſe acids, and the transfer of this principle to thoſe of the organized ſubſtances. Accordingly, all the acids which do not adhere ſtrongly to oxigen, and which eaſily ſuffer it to be taken from them, produce ſimilar effects. Thus the ſulphureous acid, that which of all acids acts the leaſt upon vegetable ſubſtances, has at leaſt the property of diſcolouring ſuch of theſe ſubſtances as have the ſtrongeſt colours, by relinquiſhing its oxigen to them. Thus the oxigenated muriatic acid, likewiſe by introducing its oxigen into the vegetable ſubſtances, not only alters their colours, bleaches them, and renders ſome liquid vegetable ſubſtances concrete, but at laſt burns theſe ſub-

ſtances, reduces them to charcoal, or converts them into acids.

10. Of all the acids that of nitre changes all the properties of vegetable matters moſt powerfully, when it is very concentrated, and eſpecially if it contain nitrous gas, it burns theſe ſubſtances with ſuch activity that it inflames ſeveral, and reduces them to the ſtate of charcoal. When a little weaker, it changes the colours, deſtroys them, or communicates to them a yellow tinge, which is unalterable or indelible. This effect of the nitric acid has long been known, but not explained: but it is evident that it is owing to the quick ſeparation of the oxigen and the large quantity of this principle, which ſuddenly ſeizes the hidrogen of theſe ſubſtances, and proceeds ſo far as to inflame them: but it is not in this violent action that the moſt uſeful influence of this acid upon vegetable compounds conſiſts. When ſtudied according to the lights of the pneumatic doctrine, this influence ſerves at preſent to acquaint us with all the properties of theſe compounds: it is in the appreciation of theſe effects that the French chemiſtry has rendered the moſt ſtriking ſervices to Natural Philoſophy, as I ſhall ſhortly ſhow.

11. Though the action of this acid varies more or leſs according to the diverſity of the compoſition of vegetable ſubſtances, and it is by examining each of the immediate materials of plants in particular, that we can appreciate all

the different circumſtances of this action, we may nevertheleſs deduce even from all the variations of the effects which it produces, a common mode, a generalized reſult, which embraces the collective whole of theſe variations, and which, while it ſerves to render them intelligible when it ſhall be neceſſary to treat of each of them, may at the ſame time ſerve to determine in what the totality of the effects which it produces upon theſe vegetable compounds conſiſts, and lead us to characterize their chemical properties: it is in this manner, and without entering into the details which belong to the following order of facts, that it is eſſential in this place to conſider the action of the nitric acid.

12. As the total tendency and the term of this action is the complete decompoſition of the vegetable compounds, their reduction into water and carbonic acid, and as it proceeds more or leſs rapidly towards this term, when we employ ſtrong and concentrated nitric acid; in order to underſtand and clearly to aſcertain all the intermediate degrees of this decompoſiion which it is capable of effecting, we take it weakened with a certain quantity of water; for example, at 28 or 30 degrees of the ordinary areometer, and frequently it is even diluted with from half its weight to twice or thrice its quantity of water. It is left to act in the cold, or its action is favoured and made to commence by the aid of a gentle temperature, or it is rendered more violent and energetic by heating it more

ſtrongly or for a greater length of time. In the firſt caſe, we have only a rare and ſlight effervefcence, the product of which is nitrous gas, mixed with a ſmall quantity of carbonic acid. In the ſecond, the proportion of this diſengagement is more conſiderable; and in the third, we may go ſo far as completely to decompoſe a portion of the acid: for as we employ from three to ſix times the weight of the vegetable matter which we wiſh to treat, there is always more than is required, in order to obtain the products which we ſeek, and the reſults which we expect.

13. In each of the circumſtances which have juſt been enunciated, the products of the action of the acid differ; the ſtronger this is, the more in general we obtain of nitrous gas and carbonic acid gas; conſequently, the more oxigen there is ſeparated from the nitric acid, the more carbon there is taken from the vegetable ſubſtance, and burned by the oxigen. The general, or the moſt conſtant and moſt abundant product of this reciprocal and ſimultaneous decompoſition, is a ſeries of different vegetable acids; ſometimes to the number of three or four, ſometimes a ſingle one, or at leaſt only two, all compoſed of hidrogen, carbon, and oxigen, whoſe characters of compoſition conſiſt in the different proportions of their three principles, and of which I ſhall give an account amongſt the immediate materials of vegetables; for I muſt here obſerve, that that which is the

moſt important and the moſt deciſive for the pneumatic doctrine, adapted to the vegetable analyſis, what moſt proves its ſtrength and ſtability, is that the acids artificially compoſed by the nitric acid acting upon the gums, ſugar, the leaves, the extracts, the woods, &c. are perfectly ſimilar both in their properties and in their intimate nature, to thoſe which are ſpontaneouſly formed by the progreſs of vegetation; which proves that the chemical art acts like the living powers which direct the growth and the function of plants.

14. The various acids which vegetable ſubſtances yield when treated by the nitric acid, proceed not only from the diverſity of theſe ſubſtances, but alſo from the manner in which they are treated by this acid: ſo that, after an attentive obſervation of what happens in theſe different treatments, we may obtain at will, as far as a certain point, ſuch or ſuch a ſpecies of vegetable acid, or determinate proportions of two of three of theſe acids: for this purpoſe it is ſufficient to ſtop at different periods, or to urge more or leſs the action of the nitric acid. We may alſo aſſure ourſelves of the point at which we have arrived in the vegetable decompoſition by the quantity and the nature of the nitrous gas, and the carbonic acid obtained; the more the gaſes are abundant, the more we are advanced in this decompoſition. By a ſeries of theſe beautiful reſults we may ſee, that as the conſequences of the alterations is the perpetually

increaſing ſeparation of a proportion of carbon, we can never make the vegetable decompoſition proceed otherwiſe than in a given progreſſion: we can never make a ſtep backwards. An acid firſt formed, when it paſſes into another acid, does not appear any more in the firſt ſtate; and we ſhall ſee that this progreſſive acidification, the moſt common and moſt ſtriking product of the energy of the nitric acid, when it has once arrived at the oxalic or acetous acids, the leaſt carbonated and the moſt oxigenated, if we wiſh to carry the nitric decompoſition ſtill further, the vegetable nature vaniſhes as it were under the efforts of the chemiſts, and the whole is reduced in his hands into water and carbonic acid. At this term, this action of the nitric acid becomes confounded with the effect of combuſtion.

15. It alſo follows from the exact, though general notions which I have juſt given, that by obſerving with much attention, and by determining with great exactneſs the quantities of nitrous gas, and of carbonic acid gas, formed and diſengaged during the different degrees of the action of the nitric acid, thoſe of the different acids obtained at different periods of this action, and finally thoſe of the water and of the carbonic acid obtained at the laſt term of this total diſgregation of the vegetable principles, we may analyze with the greateſt preciſion both the different vegetable ſubſtances,

which we may have taken for the ſubject of our operation, and the particular and ſucceſſive acids which we may have obtained in the ſeries of the different periods of this work. Thus in the courſe of a ſet of experiments which Citizen Vauquelin and myſelf jointly made upon the vegetable ſubſtances, we employed with great ſucceſs the nitric acid, in order to determine the proportions of the primitive principles, hidrogen, carbon, and oxigen, of a conſiderable number of ſubſtances, the relations of whoſe nature and compoſition it was neceſſary for us to aſcertain and compare.

16. Laſtly, there are ſome vegetable ſubſtances upon which the action of the nitric acid is not confined to producing the effects of acidification: by converting them into acids, it ſometimes changes a portion into a kind of fat oil: in others it at the ſame time produces a ſort of reſin; with the former it affords powders inſoluble in water, and ſoluble in the alkalis, without however being fuſible after the manner of the fats; with the latter it diſengages and compoſes pruſſic acid, and almoſt always produces at the ſame time ammonia. Moſt of the laſt-mentioned converſions or modifications, which are effected but ſeldom, and which take place only with the gluten, the wood, the ſuberous barks, the funguſes, &c. when treated with the nitric acid, indicate in theſe ſubſtances a compoſition very analogous to that of the

animal ſubſtances, to which in fact they approach by other characters and other chemical properties. We ſhall treat of theſe more in detail in the next order of facts.

Article VII.

Of the Chemical Properties of Vegetable Subſtances treated by the Salts.

1. AUTHORS have hitherto omitted, or nearly omitted to treat, amongſt the chemical properties which diſtinguiſh vegetable ſubſtances, of the mode of their alteration by the ſaline compounds; becauſe too little attention has been paid to this mode itſelf, and it has been thought too ſlight or too indiſtinct to be capable of ſerving as a character. It is true that chemiſts have either not yet obſerved the action of the ſalts with ſufficient attention, or not found them ſufficiently powerful, in order to apply it to vegetable analyſis; and nevertheleſs, all the facts which the practice of the arts preſents relative to the uſe of the different ſalts in the preſervation or in the preparation of a great number of vegetable ſubſtances, exhibit a ſucceſſion of phenomena which are ſufficiently characteriſtic of theſe ſubſtances in order that we ſhould not neglect the examination of them, nor reject their application to this part

of chemiſtry as uſeleſs. It is this economical object which I propoſe here to trace, with a view to determine the properties which vegetable ſubſtances exhibit when treated according to different proceſſes by various ſaline ſubſtances: to this I ſhall ſubjoin ſome reſults of chemical experiments that have hitherto been too much neglected.

2. Though the ſulphates are rarely altered by moſt of the vegetable ſubſtances in their habitual ſtate, though they experience no alteration from theſe ſubſtances in their ſimple contact, the caſe is not the ſame when we let them remain for a long time in this contact, or when we raiſe their temperature very much at the moment when it takes place. Though the ſaturated ſolutions of alkaline or earthy ſulphates in general defend moſt vegetable ſubſtances from ſpontaneous alteration, this preſervation is not prolonged beyond a certain term; after which the ſubſtances, being decompoſed in the midſt of the liquid, effect, with the aid of their hidrogen and their carbon, the decompoſition of the ſulphates, and gradually inſulate the ſulphur. It is in this manner that water charged with ſulphate of lime lets fall ſulphur, and exhales the fetid ſmell of an hidro-ſulphuret when it is left for a long time in contact with vegetable ſubſtances: it is in this manner that the filth of towns, accumulated and buried with fragments of plaſter of Paris, and moiſtened for a longer or ſhorter ſpace of time,

have filled the fragments of theſe materials with cryſtallized ſulphur, which has gradually ſeparated from the ſulphate. The ſame action takes place by time, as is rapidly effected when we violently heat ſulphates with the ſame vegetable ſubſtances, which convert them into ſulphurets by the action of their hidrogen and of their carbon. It is known, that natural waters which contain ſulphate of lime in ſolution do not poſſeſs the property of boiling eſculent vegetables well, and I have already ſhown that this depends upon their ſaturation with this ſalt; laſtly, it is eaſy to conceive that the ſame waters, when circumſtances favour the ſeparation, the depoſition and the cryſtallization of the earthy ſalt which they contain, and when they bathe on all ſides the parts of vegetables, ſuch as leaves, ſtalks, barks, muſt form upon theſe ſubſtances a covering or depoſition, a real incruſtation of ſulphate of lime, which preſerves them under this unalterable and little ſoluble covering. It is in this manner that in the graduating ſheds of ſalt works, the fragments of the bruſh-wood become encruſted with lamellated and cryſtalline ſulphate of lime which the evaporation of the water by the agitated and compreſſed air ſeparates from it inceſſantly.

3. Water charged with the triple and acid ſulphate of alumine, alum, is alſo uſed in order to preſerve various vegetable ſubſtances; but it gradually effects their decompoſition, and

mucous flakes or filaments are ſeparated from it, which announce its alteration. The utility of this ſalt in the art of dyeing is known, the advantage which is derived from it for brightening, and eſpecially for fixing and giving ſolidity to many vegetable colouring matters. In the hiſtory of theſe colours, I ſhall ſhow that the property by which this ſalt fixes them, depends upon the ſtrong attraction which the alumine exerts upon theſe matters.

4. The nitrates exert only a feeble action upon moſt of the vegetable ſubſtances, of which they render the texture more denſe, and defend it againſt its own mutability, and of which they frequently alſo heighten the tints in their coloured parts: but chemiſts ſometimes employ the nitrate of pot-aſh with another view in the examination of theſe ſubſtances; it ſerves, by expoſing the mixture with theſe ſubſtances to a high temperature to burn them, to deſtroy their hidrogen and carbon more or leſs completely, to extract from them the fixed ſaline and earthy ſubſtances, and to prove in them the exiſtence of ſome metallic oxides, more eſpecially thoſe of mangane ſe and iron. If we perform this experiment with care and in cloſe veſſels, ſo as exactly to collect the elaſtic fluids which are formed and diſengaged, we may thus determine the proportion of the hidrogen, carbon and oxigen contained in the vegetable ſubſtance which is examined, and at the ſame time that of the fixed ſubſtances which remain.

Sometimes the nitrate of pot-aſh, heated ſtrongly with the vegetable ſubſtances, yields as the reſidue a real pruſſiate, is even employed and compared in this action with that of the fixed alkalis, in order to aſcertain in theſe bodies the property of affording pruſſic acid, or the colouring matter of Pruſſian blue compared with that which different animal ſubſtances preſent.

5. It is known how great uſe is made in domeſtic economy and in the arts, of the muriate of ſoda in order to preſerve a great number of products of vegetables or vegetable parts. Thus it is cuſtomary to ſoak in brine, or the ſaturated ſolution of this ſalt, pulſe, ſome products eſpecially of the leguminous kind, grains or pods, roots, leaves, and even delicate flowers; the leaves of roſes arranged and covered with layers of this ſalt, are frequently preſerved in this manner in the ſhops of the perfumers, in order afterwards to diſtil them at a ſeaſon more or leſs diſtant from that in which they have been gathered. Some chemiſts have imagined that the muriate of ſoda, kept for a long time in contact with liquid vegetable ſubſtances was decompoſed, and that the ſoda was inſulated; but no experiment has yet proved the truth of this aſſertion. This ſalt is frequently employed in the decoctions and diſtillations of vegetables in order to permit the water to aſſume a more elevated temperature, and thus to favour the diſengagement as well as the volatilization of

ſome products, the quantity of which is augmented by this proceſs.

6. It has not yet been propoſed to uſe the ſuper-oxigenated muriate of pot-aſh in the vegetable analyſis ; it is, however, one of thoſe compounds which might prove of the greateſt utility. Citizen Vauquelin and myſelf, in our inveſtigations relative to detonations by percuſſion, have found that the vegetable ſubſtances, and eſpecially gum, ſugar, farina, like the oils, alcohol, ether, have the property of burning with great energy and fulminating by percuſſion, after having been mixed with ſuper-oxigenated muriate of potaſh. It is evident, that by performing this operation in proper apparatuſes, it would be poſſible to collect the water and the carbonic acid formed by the union of the hidrogen and of the carbon of theſe ſubſtances, either with their own oxigen, or by that which ſhould be furniſhed by the ſuper-oxigenated muriate of potaſh ; and that as this ſalt brings only pure oxigen into this powerfully decompoſing action, and leaves as reſiduum only muriate of pot-aſh, it would be eaſy to determine, with the aid of its action and of its products, the exact proportions of the principles which originally compoſe vegetables, comprehending in them even that of the fixed ſubſtances which would remain with the reſidual muriate of pot-aſh, which it would be eaſy to ſeparate.

7. The phoſphates can be of no other uſe, in the inveſtigation of the chemical properties and of the analyſis of vegetables, than that of aſcertaining the preſence of ſome earths or of ſome metallic oxides in their fixed reſidues, in their coals or in their aſhes; and that the fuſing and vitrifying action which they exert does not differ from that which is exerciſed by the ſaline or metallic ſubſtances which have already been examined. The fluates and the borates are not capable of throwing any more light upon the ſubject; accordingly, nothing has been ſaid concerning the action of all the ſalts upon the vegetable ſubſtances, and it has been abſolutely impoſſible to draw any induction from them towards the knowledge of the chemical properties which characterize theſe organized ſubſtances.

8. The carbonates exert a little more action than the three laſt mentioned kinds of ſalts upon the vegetable compounds; carbonate of ſoda is frequently employed in pharmaceutical proceſſes in order to extract more quickly, more abundantly, or more completely, ſome of the immediate materials of vegetables, by means of infuſion or decoction in water. Thus it has long been known that when water is ſharpened with a little *fixed ſalt of tartar*, or *unſaturated carbonate of pot-aſh*, more reſin is extracted from the dry woods, roots or barks; but we ſhall ſee in the ſubſequent order of facts that this more abundant extraction is accompa-

nied by a peculiar combination between the alkali and the root. It is generally known that the ſolution of carbonate of lime in a natural water, which it renders raw or hard, is an impediment to the boiling of vegetables, on account of the ſaturation of this water, which prevents its re-action upon the vegetable ſubſtance. It is alſo known that plants or their parts, immerſed with water highly charged with this earthy ſalt, by means of an exceſs of carbonic acid, become covered with depoſited and concreted molecules of this ſalt, in proportion as it quits the water, the ſolvent acid of which eſcapes into the air. By this ſimple proceſs are formed the calcareous incruſtations, the oſteocollæ, &c. when the vegetable ſubſtance is gradually deſtroyed, and when it leaves a ſort of hollow mould, which repreſents all its parts with great exactneſs. The carbonate of lime, depoſited in minute particles in this hollow ſubſtance, aſſumes the form of the vegetable; and hence ariſe the pretended petrifications, which were formerly deſcribed with a kind of complacency, and upon which, for a long time, many diſſertations were written and many abſurd ſyſtems propoſed; and of which the production is ſo ſimple and ſo eaſy to be explained ſince the diſcoveries of the pneumatic doctrine.

ARTICLE VIII.

Of the Chemical Properties of Vegetable Subſtances treated by the Metals, the Oxides and the Metallic Solutions.

1. THE metallic ſubſtances, their oxides and their ſolutions do not preſent, any more than the ſalts, to the hiſtory of chemiſtry, real inſtruments that have yet been employed in the examination of the chemical properties of vegetables, though when we are well acquainted with their nature and their energy, it is eaſy to foreſee that they may be employed for this purpoſe with great advantage. If we except ſome particular means of analyſis that have been put in practice only by Bergman and Scheele, and ſince their time by ſome chemiſts who have followed their footſteps, for examining the new acids which they have diſcovered, the action of theſe powerful re-agents has not been conſidered under any general point of view, in order to inveſtigate and appreciate, in their collective whole, the chemical properties of the vegetable ſubſtances. I ſhall here endeavour to give an idea of the advantage which may be derived from it, by inferferring from the ſmall number of facts that are known concerning this action, what it may be expected hereafter to furniſh to this new branch of chemiſtry.

2. The metallic ſubſtances collectively preſent only three modes of influence, which they experience from the chemical properties of vegetable ſubſtances. Either they are completely unalterable by theſe ſubſtances, though ſome weak alchemiſts have attributed to ſeveral vegetables the myſterious power of changing the properties of the metals, and even of effecting their tranſmutation. Or, they are more or leſs oxidable by thoſe which, bearing the character of acid, are capable of acting as ſuch by a more or leſs powerful attraction for the metallic oxides, and by the property of effecting their formation by the decompoſition of the water. Thus iron and copper are ſuddenly coloured and gradually oxidated, corroded and diſſolved by the ſour, aſcerb, and more or leſs ſtrong taſted vegetable ſubſtances as by the pure vegetable acids themſelves. Finally, the metals are coloured, ſpotted, covered and even changed into metallic ſulphurates by their longer or ſhorter contact with vegetable ſubſtances containing ſulphur, ſuch as the cruciferous plants, &c. It is evident that the two latter modifications of the chemical properties of vegetables with reſpect to mineral ſubſtances cannot afford any very great light, but only a few ideas, or general data relative to the vegetable compoſition.

3. The metallic oxides are more uſeful, and preſent a much ſtronger action than the metals

when we conſider them under the ſame relation. The quantity of oxigen which is united with them here performs functions more or leſs ſimilar to thoſe of the acids which have been examined in one of the preceding articles. Thoſe acids in particular which adhere the leaſt to this combuſtible principle, and ſuffer it the moſt eaſily to be ſeparated from their compoſition, are the moſt capable of altering the vegetable ſubſtances upon which they are made to act. It is thus that in general they tend to diſorganize, to deſtroy, to burn the vegetable compounds; and ſuch is the laſt term of their action upon thoſe compounds. But they do not always carry their energy to this extreme point; frequently they yield only a portion of their principle, which penetrates the vegetable ſubſtances, thickens and condenſes, or ſimply oxidates, without decompoſing and completely deſtroying them. Such is the habitude of the vegetable oils when heated with the metallic oxides, and which, in the preparation of plaſters, aſſume conſiſtence at the ſame time that they acquire a kind of ſaponaceous nature. It is by the ſame property that ſo many vegetable liquors become more or leſs denſe, flaky and tenacious, when metallic oxides are added to them, and particularly when they are heated with theſe ſubſtances.

4. A particular action takes place between the metallic oxides and the colouring parts of vegetables: though it may be referred in general

to what has already been explained, it muſt however be remarked, that it is ſtill ſtronger on account of the attraction which ſubſiſts between theſe two kinds of bodies. The oxigen ſeems in fact to be the cauſe of the connection which unites theſe two ſubſtances ſo cloſely with each other, for the metals of theſe oxides do not preſent the ſame property of combining with the colouring matters; but the combination thus formed does not admit of the ſeparation of this principle; it remains united at the ſame time both to the oxide and to the colouring matter, the colour of which it exalts, fixes, and renders more permanent.

5. The ſolutions of the metals in acids produce a great variety of effects with vegetable matters, and their action differs according to the nature of theſe compounds. We ſhall ſee, in the hiſtory of the vegetable acids, how many different characters they preſent with the moſt of theſe ſolutions, and what effects ſimple and complicated attractions take place when theſe different ſubſtances are mixed with each other. It is neceſſary, in order to comprehend the reciprocal actions of the metallic ſolutions, and of the vegetable compounds, firſt to ſeparate in the mind thoſe effects which can be produced by the ſaline bodies analogous to thoſe deſcribed in the fifth ſection of this work, which are frequently found to conſtitute part of theſe compounds; otherwiſe we might attribute to the vegetable matter what belongs

only to ſubſtances foreign to its nature, which may in this manner be mixed with it. Thus the precipitations produced by the ſulphates and the muriates, which the vegetable liquids ſo often preſent when we mix them with the nitric ſolutions of moſt of the white metals, muſt firſt be ſeparated from the chemical effects which the vegetable ſubſtance is capable of producing. Thoſe effects are known by the form, the colour, and eſpecially by the examination of the precipitates.

6. When we admit this firſt and eſſential diſtinction, and in ſome meaſure ſubtract from the chemical phenomena produced by the vegetable ſubſtances mixed with the metallic ſolutions, thoſe which belong to the ſalts already known, we find that the ſubſtances of this order are either preſerved, or condenſed, or coloured, or burned, or decompoſed and precipitated by the metallic ſalts. Nothing is ſo frequent as the more or leſs intenſe coloration of white vegetable ſubſtances by the contact of metallic ſolutions; and beſides the ſpots of all kinds with which the linen cloths employed in chemical laboratories become covered by the contact of theſe ſolutions, this kind of alteration is proved by the grand and beautiful reſults of the art of dyeing. The precipitation occaſioned by the ſame compounds, added to the vegetable liquids, takes place eſpecially with the ſaps, expreſſed juices, infuſions, and decoctions. As the metallic ſalts are themſelves

decompoſed by theſe mixtures, Citizen Berthollet has propoſed to employ the decoction of Peruvian bark, in order to deſtroy, even in the ſtomachs of perſons who have taken them inconſiderately or by miſtake, the effects of the ſolutions of tartrite of antimony and pot-aſh, and of the ſuper-oxigenated muriate of mercury.

Fourth Order of Facts relative to the Vegetable Compounds.

Of the different Vegetable Matters in particular, or of the immediate Materials of Vegetables.

ARTICLE I.

Concerning what is to be underſtood by the expreſſion or term of immediate Materials of Vegetables, and of their ſeat in the vegetable organization.

1. I HAVE hitherto ſpoken only of vegetable compounds in the aggregate, and have conſidered them only as if they formed one and the ſame ſubſtance, the nature and the general properties of which I have explained; but no one is ignorant that the matters extracted from vegetables are really very different from each other in their form, their conſiſtence, their taſte, their ſmell; no one confounds ſugar

with gum, or theſe two ſubſtances with oil, or oil with wood ſtrictly ſo called. The uſes to which each of theſe principal vegetable matters is applied for the purpoſes of life, teach every one to diſtinguiſh them from each other, and ſhow that it is not only in the different ſtructure of their parts, for example of their roots compared with their ſtalks, their leaves, their flowers, &c. that vegetables differ from each other, but even in the particular and different bodies, which each of their parts contain ſeveral at the ſame time. Thus the ſweet almonds preſent upon their ſkin a reddiſh powder which is removed from them by friction, in their interior part an oil which is extracted by preſſure, and a pulverulent maſs, friable and white like ſtarch, which remains after the expreſſion of the oil.

2. This is the ſimple notion of what I term immediate materials of vegetables; they are all ſubſtances varying in their properties, in their taſte, their ſmell, their ſolid or liquid ſtate, their conſiſtence, their nutritive, medicinal, or poiſonous properties; which may be ſeparated from the different parts of plants, and eſpecially from the ſame part, and which by their arrangement and diſpoſition in this part do immediately conſtitute it. Their general or diſtinctive character is their ſeparate exiſtence in the different parts of the plants, and eſpecially the poſſibility of their being ſeparated or extracted without experiencing alteration or change: ſo that

they are obtained abſolutely ſuch as they were in the vegetable compounds, and without their having been cauſed to undergo any alteration capable of rendering their nature different from what it was in the organs of the plants of which they really formed integrant parts.

3. It is on this account that, when conſidered with reſpect to the vegetables to which they belong, and which are more compounded than they, becauſe theſe materials only conſtitute their different parts, they were firſt termed the immediate principles of plants, either becauſe they were found to poſſeſs the property and the character of really forming the vegetables by their union, or becauſe they were ſeparated from them by an immediate analyſis, or by immediate means. This is the reaſon why I have elſewhere deſignated, by the name of *immediate analyſis*, that in which we obtain by a firſt operation, and without complicated apparatus or proceſſes, the matters contained in a compound; and I have choſen the principal and moſt ſtriking example of this manner of analyzing vegetables. It is ſufficiently evident that theſe materials could not be termed *principles*, except ſo far as they were compared with the entire plants of which they are compoſed; but this is an expreſſion which ought not to be retained, becauſe they are not really principles: accordingly chemiſts formerly employed them to furniſh an example of what they called prin-

ciples principiated, or formed themſelves of other principles much more ſimple than they. I have therefore thought I ought to relinquiſh this ancient expreſſion of *principles* of vegetables, and ſubſtitute inſtead of it, that of *immediate materials*, which very well expreſſes the notion which ought to be formed of them relatively to the vegetable compoſition.

4. It is ſcarcely neceſſary here to repeat, that all the immediate materials are the products of the work of vegetation; it is only of importance to obſerve, that a vegetable ſubſtance, or a vegetable part, never conſiſts of a ſingle matter only, but of ſeveral at a time, which may be ſeparated and obtained, disjoined from each other. It follows that each of the immediate materials of vegetables muſt be placed in a particular kind of organs, and that its ſpecial and in ſome meaſure individual compoſition, is owing to the particular ſtructure of each organ. However, it is not to be ſuppoſed that there are as many orders of veſſels or of cells, as there are of immediate materials of vegetables: for the number of theſe amounts at leaſt to twenty, as I ſhall ſoon ſhow; whilſt the number of orders of veſſels does not exceed five that are different from each other, as I have ſhown in a preceding article. It follows therefore, that each claſs of textures, or of the organs of vegetables, contains a certain number of immediate materials different from each other. What I am about to ſay concerning

the method of obtaining theſe materials will confirm this aſſertion, as we may actually extract from a ſingle texture ſometimes three or four of theſe different materials.

ARTICLE II.

Of the Manner of extracting the immediate Materials of Vegetables.

1. THE character of the immediate materials of vegetables being to preſent all the properties which they had in the plants themſelves, of which they formed part, it is evident, that in order to obtain them ſuch, we muſt employ means which cannot in any manner alter them. If each of theſe materials were particularly placed in a very diſtinct ſituation, it would be ſufficient to know this ſituation for each of them, and to extract the ſubſtance which we wiſhed to obtain by detaching this part; and in this caſe the proceſs would be entirely mechanical. This method is practicable only for ſuch of the materials as are contained, in the liquid form, in particular cells, or with ſuch as in the ſolid or pulverulent form are ſeparated and covered with a cruſt or membranous covering, or laſtly, with ſome which, being inſulated and produced by a particular excretion, are found pure on the outſide of

the vegetables, or of ſome of their organs, whether upon the bark, or upon the leaves, or between the open parts of the flowers, or upon the ſurface of the fruits.

2. It reſults from this diſtinction, that there are firſt of all three mechanical methods, all equally ſimple and equally certain, of extracting or obtaining ſome of the immediate materials of vegetables. When theſe materials, frequently ſuſceptible of becoming thick in the air, iſſue ſpontaneouſly in the liquid form from certain points of the ſurface of plants, whether through the extremities of dilated veſſels, or through the fiſſures and crevices which are formed in conſequence of a kind of plethora or turgeſcence, which has violently diſtended the ſides of theſe veſſels, we ſimply gather them by hand. It is in this manner that the gums, the reſins, and the balſams, are collected: nature herſelf preparing theſe juices in a peculiar claſs of veſſels, cauſes them to iſſue out by a real ſecretion and excretion ſimilar to what takes place in animals. I have indicated this general proceſs elſewhere, under the name of the natural mechanical analyſis. We ſee that it affords immediate materials.

3. Some immediate materials of vegetables, though very abundant in the interior of theſe organized and living bodies, iſſue from them with difficulty and in ſmall quantity, or even in ſome circumſtances not at all. Human induſtry has diſcovered how to remedy this inconvenience,

venience, and to adopt a ſimple method of augmenting their tardy emiſſion at pleaſure, or determining it when it does not take place ſpontaneouſly. Thus the reſinous trees are bored with tools, in order to obtain the juices which then flow abundantly; the heads of poppies are cut to extract from them the white juice, which, as it dries upon the exterior ſides of theſe capſules, forms opium; and the leaves of the aloe, the ſtalks of the euphorbium, the roots of the ſcammony, the trunks of many trees, in order to obtain the extractive or gum-reſinous juices which are contained in them more or leſs abundantly. It is alſo by this proceſs that the manna is extracted from the aſh, &c. the ſap from the birch, the yoke-elm, the beech, the vine, the ſaccharine juice from the ſugar-maple, the elaſtic gum from the hevoea-caoutchouc.

4. In other caſes, when the proper juices which repreſent ſome immediate materials of vegetables, are incloſed in numerous veſicles arranged in ſome parts that are inſulated, or may eaſily be inſulated, theſe veſicles are opened by means of raſps, or the more or leſs ſoft and delicate texture which covers them is taken off, and they are expreſſed either with the hand or with the aid of a preſs: in this manner the juice is ſeparated from the ſolid and diſorganized parenchyma belonging to the veſicles in which it was incloſed. Thus the volatile oil

is extracted from the cellular ſkins of the lemon, orange, and bergamot.

5. This kind of diſſection, though groſs and diſorganizing, is not always ſufficient for obtaining ſeveral of theſe liquid materials. When they are deeply hidden in veſſels which occupy the whole thickneſs, the whole continuity, and eſpecially the deep part of a freſh vegetable, or in cellules formed in the very centre of the fruits; when theſe juices cannot be extracted except after the whole texture has been entirely bruiſed or completely deſtroyed; when they are intimately mixed with pulpy or paſty ſubſtances which are impregnated with them: we are then obliged to bruiſe, to grind, or to pulverize theſe vegetables or parts of vegetables, and to ſubject the pulp or the paſte which is thus formed to the more or leſs violent force of a preſs. In this manner the oily and feculent ſeeds are treated, in order to extract the oil from them, and the tender and ſucculent plants, in order to ſeparate their juices. Bruiſing or violent preſſure generally cauſes ſeveral of the liquid immediate materials to run out at the ſame time, with part of the fibrous, mucous, feculent, or ligneous parenchyma, which formed the ſolid portion; but repoſe and decantation are generally ſufficient for purifying theſe materials, and ſeparating them with ſufficient exactneſs, without any other means.

6. Filtration through linen or paper is one

of the moſt ſimple and moſt certain means of ſeparating ſeveral of the immediate materials of vegetables when confounded together in a liquid: the light fecula, which renders the juices turbid, the mucous juices mixed with reſinous or oily bodies that do not paſs through fine paper already moiſtened, are very eaſily ſeparated from each other by this mechanical proceſs. Mere repoſe is frequently ſufficient for obtaining this ſeparation. Thus, for example, the acid expreſſed juice of lemons, of oranges, of currants, of cherries, &c. when kept for ſome time, depoſits a more or leſs conſiderable quantity of inſipid gelatinous mucilage, which was at firſt diſſolved in the acid: but almoſt always this ſeparation, this kind of parting by the operation of time, is effected only by virtue of an intimate alteration, of a more or leſs advanced change in the very nature of the vegetable liquids, which, as I have already ſhown, are extremely ſubject to decompoſition. We ought not therefore to have recourſe to this means for obtaining the different immediate materials contained in theſe liquids, except in the caſes where they ſeparate very ſpeedily, and before we have cauſe to ſuſpect any alteration in the combination of theſe materials; an alteration which ſometimes takes place very ſpeedily.

7. When the immediate materials which we wiſh to ſeparate are in the ſolid form, and ſuſceptible of aſſuming that of powder by trituration or pounding, after they have been reduced

into a pulp or paſte, either with the water of verdure of the vegetable parts which contain them, or of foreign water which may be added to them while pounding or bruiſing them by different means,—they are then diluted with a large quantity of freſh water, which by ſeparating all the pulverizable molecules, from each other keeps them firſt for ſome time ſuſpended, and afterwards depoſits or precipitates them more or leſs pure, inſulated and ſeparated, or deprived of the portion of ſoluble matter foreign to the pulverulent materials that remain in the water. This kind of waſhing is particularly employed in order to obtain the amilaceous and the fibrous fecula.

8. All the means that we have hitherto enunciated are entirely mechanical; there are ſome others which, without being equally ſimple but appertaining to ſome chemical operations, do not however require inſtruments or actions ſufficiently powerful to alter, or at leaſt ſenſibly to change the nature and the compoſition of the immediate materials of vegetables. Such is, in ſeveral circumſtances of this extraction of the immediate materials of plants, is the action of fire. Frequently theſe materials, being deeply hidden or intimately contained in the interior of the vegetable cells, where they are at the ſame time ſolidified and attached to their ſurface, cannot be extracted from them by mechanical means; ſimple diſſection, pounding, waſhing, are then no longer capable of detaching them

from the places to which they adhere, and ſeparating them in order to obtain them alone. Frequently alſo, though they do not poſſeſs the ſolid form which I have juſt mentioned, but are in the liquid form, their imperceptible drops are contained in ſuch ſmall cells, and at the ſame time ſurrounded with ſuch dry teguments, that it would be in vain to attempt to extract them by all the proceſſes of trituration and of preſſure that have been indicated. In this caſe by macerating the vegetable parts which contain them for ſome hours in cold water, the ſides of the cells in which they are contained become ſoftened and diſtended; the ſmall drops or the lamellated flakes of the immediate materials of which I ſpeak begin to be inſulated, and detached; and by afterwards applying a gentle heat to the vegetable parts thus macerated, the caloric which penetrates the molecules of the immediate materials we wiſh to obtain fuſes them when they are ſolid, detaches them more when they are liquid, and at laſt volatilizes them, gives them the form of vapour, and enables them to be extracted by diſtillation. This is what happens in the diſtillation performed in order to obtain the volatile or eſſential oils. It is evident that this chemical proceſs is founded upon the property which theſe immediate materials poſſeſs, of being fuſed and reduced into vapour without undergoing any kind of alteration in their nature and compoſition. There are, however, very few of theſe materials that are ſuſceptible of being diſengaged in this manner without alteration, by the mere fuſing and volatilizing action of the fire.

9. But ſince many other of theſe materials, placed in the ſame condition as the preceding, that is to ſay, incloſed in ſmall cellules, or thick and ſolid, ſo as not to be capable of being extracted by any means of tapping, are at the ſame time ſoluble without being altered by water, alcohol, the oils, and ſometimes even by the acids very much diluted: for want of other practicable proceſſes for their extraction, one or the other of theſe ſolvents is uſed in order to obtain them ſeparate. Sometimes indeed two, or even more, of theſe immediate products of vegetation are diſſolved at the ſame time in the ſame liquid employed for extracting them: different means are then uſed in order to obtain them ſeparate; ſlow evaporation, the admixture of different liquids, and ſometimes even certain appropriate re-agents anſwer this purpoſe. Here alſo, as in all the foregoing proceſſes, we imitate the method of nature, which, by the aqueous ſolution of the ſap or of the proper juices, carries the immediate materials of plants towards the ſurface of theſe organized bodies, and frequently cauſes their ſeparation by evaporation to enſue by the atmoſpherical air and heat.

10. In a word, all the operations, whether mechanical or chemical, but not alterant, which

are practiſed in order to procure the different immediate materials of vegetables, and the different products to which vegetation has given riſe, however varied they may be, even in the conciſe account which I have given of them, and ſtill more ſo in the genius and the reſources of the chemiſt who wiſhes to obtain them, coincide in this ſingle point, that they ſeparate without cauſing them to undergo any change which can alter their nature, the different matters which are contained in an entire vegetable; that they enable us to diſtinguiſh theſe matters, and afterwards to examine each in particular, in order to determine their characters, properties, relative differences and compoſition; ſo that the mutual extraction and ſeparation of all theſe immediate materials is the firſt ſpecies of analyſis that is applied to vegetables.

ARTICLE III.

Of the Enumeration and Claſſification of the immediate Materials of Vegetables.

1. WHEN we have ſucceeded in finding the means of extracting and ſeparating from each other, the different matters which form the vegetable compounds, and have thus become acquainted with what are termed the immediate

materials of plants, the firſt queſtions which preſent themſelves to the mind relate to the number and difference of thoſe materials themſelves. We aſk ourſelves by what characters we may know this difference of the materials from each other, and to what number their ſpecies, or rather their genera, amount. Under this double queſtion is comprehended the expoſition of what I term the claſſification and enumeration of the immediate materials. In order to underſtand them well, we muſt revert to the period when chemiſts, informed by the proceſſes of the arts, and eſpecially by the pharmaceutical manipulations, that they might extract from a vegetable, or from the different parts of a vegetable, from its root, its ſtalk, or its leaves, matters different from each other,—and having endeavoured to compare theſe matters with each other, muſt have found that, notwithſtanding the very remarkable difference ſubſiſting between the numerous vegetables that ornament the ſurface of the globe, approximations may however be eſtabliſhed between materials which were ſeparated, frequently even from plants the moſt oppoſite to each other in their ſtructure and their properties.

2. It was then that forming for the firſt time a diſtinct idea of the vegetable compoſition, they diſcovered that ſimilar materials were found in all plants, and they began to form thoſe approximations which I have juſt mentioned. They ſaw that amongſt theſe materials

ſome were liquid, others more or leſs ſolid; ſome ſoluble, others inſoluble in water; ſome had a glutinous conſiſtence, others more or leſs fluidity; that ſome were inflammable, and immiſcible with water; that others had not the ſame inflammability, nor the ſame immiſcibility; in a word, they thus formed ſeries of characters or properties which ſerved to diſtinguiſh thoſe materials from each other. Hence gradually aroſe the diſtinction and the claſſification of what they have ſo long termed immediate principles of plants. The number of theſe principles ſoon increaſed in proportion as the reſearches of chemiſts were multiplied, and as the neceſſity was felt of regularly arranging theſe immediate materials in a methodical order.

3. Suppoſing that we already know, and are able to collect, all the immediate materials, the union of which forms in particular the collective whole of the vegetable; let us imagine, in order to repreſent this whole, and to proceed with order to the vegetable analyſis, all the plants mixed and pounded as it were, forming together only a ſingle maſs produced by vegetation conſidered in its totality, ſubjected afterwards to the different means of extraction which I have deſcribed, and ſeparable into a ſeries of different matters; let us imagine this ſeparation, carried to the point which we cannot paſs without deſtroying the compoſition itſelf, and changing the nature of thoſe different matters. This is the notion which we have

to form of the products of the immediate analyſis, or of the immediate materials of vegetables. Each of them is then no longer conſidered as belonging in particular to ſuch or ſuch a plant, but to the collective whole of vegetable compoſition, to the whole maſs of exiſting plants. Each of them, of an identical general nature, repreſents in ſome ſort the ſame matter exiſting in all vegetable bodies. For example, the gummous juice and the ſaccharine juice are the ſame in all vegetables; in every plant, or part of a plant, from which they have been taken, they are exactly the ſame: ſo that with only a few vegetables, provided we chooſe them in ſuch a manner that they can furniſh all the compounds which have hitherto been admitted amongſt the immediate materials of plants, we may be conſidered to proceed in the vegetable analyſis in its whole extent.

4. Undoubtedly we cannot yet be certain that we have arrived at the complete diſcovery of all the immediate materials of vegetables: that we have extracted and know them all, that there remains nothing more to be diſcovered amongſt theſe materials;—ſuch an aſſertion would even be repelled by the eight or ten new principles, acids and others, that have been diſcovered within theſe twenty years paſt, which have been added to the catalogue of thoſe which had before been known and diſtinguiſhed. Undoubtedly this catalogue, ſo far from being completed at the preſent day, is perhaps incapable

of ever being ſo, nor can we confine within any limits what ſtill remains to be done in this reſpect by the human intellect. However, it is neceſſary to eſtabliſh a kind of boundary in the preſent ſtate of our knowledge; it is neceſſary while conſidering the ſcience at the point of perfection to which it has arrived, even were it only in order to draw up the catalogue of the notions that have been acquired, to preſent an enumeration of theſe materials; and it is in order to preſent this enumeration that the moſt able and moſt ingenious chemiſts have particularly occupied themſelves for ſome years paſt.

5. Some have taken for the baſis of the claſſification which they have adopted, the mode itſelf in which they were extracted, or the order of analyſis. Thus Rouelle, in his table of the vegetable kingdom, has treated ſucceſſively of the analyſis of plants, or of the materials ſeparated by a gentle or a violent fire, by water, by fermentation, and by alcohol; others have followed a method relative to the order of the diſſection of the plants, or of the natural and ſimple extraction of their materials with reſpect to the ſtructure or the different vaſcular ſyſtems of vegetables: this is the courſe which Bucquet has followed. Some others have founded their principal diviſions upon the properties made uſe of in common life, or in the arts. Moſt have conſidered them in no other point of view than that of medicinal preparations, and have followed only a

pharmaceutical order. A very great number have ſimply treated of theſe materials according to the ſeries of different operations to which they are ſubjected. None of theſe methods has yet been ſyſtematic, and founded upon a compariſon of the properties of the different immediate materials of vegetables.

6. When we conſider in the moſt general manner, or under the moſt extenſive point of view, the different modes of claſſifying the products, or immediate materials of plants, we find that only four principal methods of diviſion or of claſſification can be admitted amongſt them. And in fact we may follow firſt the anatomical order, and examine ſucceſſively the materials of the roots, the bark, the ſtems, the woods, the leaves, the flowers, the fruits and the ſeeds, or even directing our attention to the interior ſtructure, thoſe of the common, the proper, the utricular, and the cellular veſſels. But this firſt order repreſents inceſſantly the ſame objects which we ſhould thus be obliged inceſſantly to reconſider; for each of the parts of plants, though very different in their ſtructure and reſpective ſituations, frequently contain matters analogous to thoſe which are contained in others, and it is evident that the mere ſeat or place does not indicate a difference ſufficiently conſtant or ſufficiently marked to afford a certain baſis for the diſtinctions to be eſtabliſhed between thoſe different materials.

We may chooſe for this baſis the properties themſelves of the materials, diſtinguiſhing them into nutritive or alimentary, medicinal, combuſtible, textile, fermenteſcible, ſolid and permanent, &c. But this ſecond method, which may have its advantages in the applications of the ſcience, has however too few relations with the philoſophical views, and the individual progreſs of the latter, for it to be capable of affording the advantage which is ſought in it.

7. A third method of diſtinction between theſe ſeveral vegetable bodies or compounds might be founded upon the really chemical characters, or the intimate properties by which they are ſeparated and known. For example, ſome immediate materials are mucous, others are ſaccharine, ſome are acid, ſome oily and inflammable; ſome are coloured, ſome ſolid and inſoluble, and ſome approach to the animal ſubſtances. We might even combine with this firſt diviſion that which conſiders the materials with reſpect to their ſtate or conſiſtence as liquid, ſoft, fibrous, glutinous, lamellated, pulverulent; thoſe alſo which diſtinguiſh them by their taſte into ſweet and inſipid, ſweet and and ſaccharine, acid, acerb, bitter, acrid; by their ſmell, into odorant, inodorous, fetid, aromatic. This method of diſpoſing the materials of vegetables is one of the moſt uſeful and moſt philoſophical; it depends upon the chemical properties on the one hand, whilſt on the other it leads to the knowledge of the advantageous

or uſeful properties: it therefore in every reſpect merits the preference beyond the two firſt, and it will ſoon be ſeen that it is the method to which I approach the neareſt.

8. Laſtly, the fourth method, the moſt philoſophical of all, which ſuppoſes the greateſt advancement in the ſcience, and which can yet be preſented only in idea or expectation,—which, in a word, is far from being able to be brought to that point of perfection which it may hereafter attain, and which will then be followed with one accord by all who ſhall occupy themſelves with the ſtudy of nature, is that which, founding itſelf upon the progreſs of vegetation, of vegetative chemiſtry, ſhall arrange the immediate materials according to the order of their ſucceſſive formation in plants, and diſpoſe theſe materials according to time and the periods of their appearance and their creation. In order to comprehend this laſt diviſion perfectly, I muſt here mention, that notwithſtanding the little real progreſs which chemical ſcience has yet made in the knowledge of the phenomena of the growth, and of the particular vitality of the plants, it has however already elevated itſelf ſo much in its conceptions and experiments, as to know that the immediate materials of vegetables are formed ſucceſſively, at different periods of vegetation, that each of them belongs in ſome meaſure to one of theſe periods; for example, the mucous ſap and the mucilage to the firſt periods of vegetation,

the ſaccharine ſubſtance to the germination and the maturation of the fruits, the ligneous ſubſtance to the growth and fruteſcence, the oil and the wax to the fructification; that all theſe different materials are only progreſſive modifications of the ſame matter, of a ſingle primitive, ternary or quaternary compound, which ſeems to commence with the ſappy gum, and to finiſh with the wood and bark; and that by thus inveſtigating, either from an attentive examination of the phenomena of vegetation themſelves, or by a comparative analyſis of the different vegetable materials, an analyſis placed in ſome meaſure at the other extremity of this philoſophic chain, we ſhall be able hereafter to find out the order, the ſucceſſion, the epocha of the formation of each immediate vegetable matter.

9. It is by combining theſe two baſes, as far as the ſtate of the ſcience has permitted me, the chemical characters on the one hand, and the ſucceſſion or the relative period of the formation on the other, that I ſhall here give the claſſification and the enumeration of the immediate materials of vegetables, the number of which I reduce to twenty different matters, viz.

A. Sap.
B. Mucous matter.
C. Sugar.
D. Vegetable albumen.
E. Vegetable acid or acids.
F. Extractive.
G. Tanin.
H. Starch.

I. Gluten.
K. Colouring matter.
L. Fixed oil.
M. Vegetable wax.
N. Vegetable oil.
O. Camphor.
P. Reſin.
Q. Gum reſin.
R. Balſam.
S. Caoutchouc.
T. Ligneous matter.
U. Suber.

10. I muſt obſerve, that of the twenty materials which I have juſt enumerated, the ſix firſt are frequently diſſolved in the water of the plant, circulating with the ſap, or are ſuſceptible of diſſolving in the water which we add to them; the three following, the ſtarch, the gluten, and the colouring matters, have a pulverulent or lamellated form; the oily ſubſtances, from the fixed oil to caoutchouc incluſively, inflammable and inſoluble in water, are incloſed in particular cells or veſſels; and the two laſt, the ligneous ſubſtance and the ſuber, form the ſolid inſoluble part, the common ſupport and integument of all the parts of vegetables. Of theſe twenty ſubſtances, there are at leaſt four which have been miſtaken by the chemiſts before me, or which they have not diſtinguiſhed from the other materials, or have neglected to ſtudy as particular products; theſe are the albumen, the wax, the ligneous matter, and the ſuber. Each of theſe immediate materials,

terials, the properties of which I am about to examine, ought to be conſidered as a peculiar genus of vegetable compounds, to which the ſpecies or varieties will be referred, according to the ſlight differences they poſſeſs in the different vegetables: in examining each of theſe bodies, I ſhall conſider ſucceſſively and in the ſame order for all.

A. The ſeat or ſituation which it occupies.
B. The proceſſes for its extraction.
C. Its chemical properties.
D. Its chemical products.
E. Its ſpecies or varieties.
F. Its uſes.

ARTICLE IV.

Of the firſt of the immediate Materials of Vegetables, namely the Sap.

A. *Seat.*

1. I CONSIDER the ſap as the firſt of the immediate materials of vegetables, becauſe this is the liquid which in fact ſhows itſelf the firſt in vegetation. When the motion which takes place in trees and plants at the firſt warmth of ſpring, and after the long ſleep into which they have been ſunk by the cold of the winter, begins to dilate their buds, and cauſe their leaves

to unfold themſelves, the ſap which ſwells the common veſſels, and perhaps even at this period all the orders of veſſels of theſe organized bodies, opens as it were, by its progreſs, the ſcene of vegetation; it aſcends from the root into the ſtem, and from this by the medullary prolongations under the bark, and to all the extremities of the trees and plants which it dilates, which it develops, and which cauſes it to grow with greater or leſs activity. In this plethora, this general turgeſcence of the veſſels of theſe bodies, ſome parts of their ſides are unable to reſiſt the diſtenſion which they experience; fiſſures, crevices are formed; the ſap opens itſelf a vent on all ſides, and flows out with more or leſs force, either by the cortical fiſſures, or in the vicinity of the buds, or at the extremity of the ſtalks.

B. *Extraction.*

2. If we cut young branches at this period of the motion of the ſap, and place the extremity that has been cut in a bottle, there iſſues out a quantity of this liquid ſufficient to enable us to obtain nearly half a kilogramme (from twelve to ſixteen ounces) in twenty-four hours. If we pierce the trunk of the tree horizontally with an auger, there runs out a ſufficiency to enable us to collect quantities uſeful in ſeveral of the arts, and eſpecially in the preparation of an acidulous and vinous liquor, much employed and very uſeful in ſeveral of the foreſts of Germany.

many. In America, the ſap of ſeveral kinds of maple is obtained by the ſame proceſs, in order to extract from it ſugar ſimilar to that which is furniſhed by the ſpecies of gramen cultivated in the colonies of the Europeans in America. It was long ago known, from theſe two kinds of experiments upon a very large ſcale, that the ſap of trees contains ſaccharine matter, and that it is ſuſceptible of fermenting or yielding a vinous liquor; but theſe firſt notions were very remote from the remarkable diſcoveries that have been made ſome years ago upon this ſubject by Citizens Vauquelin and Deyeux.

C. *Phyſical Properties.*

3. Sap is a limpid and colourleſs liquid, which was long believed to be pure water, and which on that account was denominated *tears.* Its taſte is ſometimes inſipid, ſlightly ſaline, ſometimes ſweet, almoſt always briſkly acid or acidulous, Immediately after it has been extracted from the trees, it contains no foreign ſubſtance, no ſolid matter, no flakes, and it has no colour; it often froths much upon the ſlighteſt agitation. When we pierce, or even when we ſaw trees as far as their centre, and apply the ear cloſe to the cut of the ſaw, we hear a crackling or a ruſtling noiſe, perfectly ſimilar to that of bubbles of air, when, by the effect of compreſſion, they paſs through a liquid, from which they eſcape with difficulty. When kept for ſome time in a well-

cloſed bottle, a ſpontaneous effervefcence takes place, which puſhes out the cork, as is done by fermenting wine: it then becomes ſtrongly acid, powerfully reddens the blue vegetable colours, and is turbid in a more or leſs ſenſible degree. Its conſiſtence is never mucous or ropy; on the contrary, it is very light and liquid. It cannot therefore be confounded with any of the materials that are to be examined after it, becauſe it has none of their apparent characters.

D. *Chemical Properties.*

4. Sap expoſed to the fire becomes filled with bubbles, ſwells and readily yields carbonic acid gas; when it is evaporated, it diffuſes a ſtrong ſmell of vinegar; it affords an extract of a beautiful red colour mixed with tanin; the latter exiſts in the ſap of the oak and the beech; it ſometimes affords a ſmall quantity of albumen, but then it contains no tanin; we find ſaccharine matter in it, eſpecially in that of the maple and the birch; it becomes brown during its evaporation; it alſo affords carbonate of ammonia when it is diſtilled to dryneſs. Amongſt its products we diſtinguiſh vinegar, which is the more abundant, the longer it has been kept after its extraction from the trees, before the period at which it is ſubjected to the action of the fire. In its coal we find carbonate of pot-aſh, carbonate of lime, muriate and ſulphate of pot-aſh. Theſe are the phenomenona deſcribed by Citizens Deyeux and Vauquelin, after the treatment of the ſap by the fire.

5. When we leave ſap expoſed to the air, it aſſumes the yellow and the brown colour; it depoſits many flakes which Citizen Deyeux believes to be a kind of vegeto-animal or glutinous ſubſtance, held in ſolution by the acetous acid. It ſoon ferments, yields a great quantity of carbonic acid gas, becomes more intenſely ſour, and forms a kind of vinous and acidulous liquor, from which we may extract alcohol by diſtillation. If we leave it for a longer time to become altered in the air, it aſſumes a fetid ſmell, becomes very brown, depoſits a filamentous and gluey mucilage blackiſh at its ſurface; at laſt it becomes ammoniacal. Thus it is ſuſceptible of the three fermentations, the vinous, the acid, and the ammoniacal or putrid,

6. Sap mixes in all proportions with water, which dilutes, extends, and diſſolves it, when it is thick and viſcous, which alſo facilitates the ſeparation of its different flakes, and the motions of ſpontaneous alteration, which the different materials of which it conſiſts are capable of experiencing. It only acquires leſs colour after having been diluted with water.

7. The powerful acids expel from it the carbonic and the acetous acids, and form calcareous ſalts with a baſe of pot-aſh, which are found by evaporating the ſaps to which they have been added. They alſo ſeparate from them concrete flakes, at leaſt in ſeveral kinds of ſaps. When they are concentrated, particularly the ſulphuric acid they burn and blacken them, by

carbonating the extractive and glutinous materials which they contain. The nitric acid converts their extracts into mucous and oxalic acids; the latter ſhows that lime exiſts in them.

8. The alkalis combine quickly and eaſily with ſap; they ſaturate the exceſs of acid, which it almoſt always contains; they prevent its depoſition and precipitation ſo quickly as it would do ſpontaneouſly; they retain in ſolution the tanin, the extracts, or the vegeto-animal ſubſtance which it ſometimes appears to contain.

9. The ſalts, properly ſo called, merely diſſolve the materials of ſap, check its fermentation, preſerve its integrity without cauſing it to undergo any alteration, and without being able to aſſiſt in rendering us acquainted with its principles.

10. The ſame is the caſe with the metals and metallic ſolutions; they cannot afford us much light with reſpect to the nature of ſap: the firſt become coloured or diſſolved; the ſecond ſometimes unite with the acids which are contained in it, and ſaturate them; metallic ſolutions are entirely precipitated in it, either by the extractive matters, or by the acetites which form part of this vegetable liquid, and act upon the metallic ſalts by double elective attraction.

11. Citizen Deyeux has concluded from his experiments that ſap is a compound liquor, containing calcareous acetite and a vegeto-animal matter united with the acetous acid: it is to

this matter he attributes the ſpontaneous precipitation of the ſaps in the air, the formation of the ammonia, and the ſmell of burned rope, which is diffuſed by the reſiduum of its evaporation when placed upon ignited coals. He compares this ſubſtance with the glutinous matter of cheeſe, equally ſoluble by the acetous acid, and forming ammonia.

12. After the experiments of Citizen Deyeux, made in Germinal and Floreal of the year 4, Citizen Vauquelin inſtituted a ſimilar inquiry reſpecting the ſaps in the ſame ſeaſon of the year 5. The firſt had examined the ſap of the yoke-elm and the vine; the ſecond has analyzed thoſe of the elm, the birch, the beech, and the yoke-elm: in all he has conſtantly found acetite of pot-aſh and acetite of lime, ſometimes acetous acid in exceſs, ſometimes carbonate of lime and carbonic acid, a ſaccharine matter, tanin, gallic acid, two very high-coloured extracts; the one ſoluble in alcohol, the other only ſoluble in water. Hence he concludes, that all the ſaps are acid, that they contain either acetous or carbonic acid, or both at once; that part of the acetous acid is combined in them with the pot-aſh, and the other with lime: that the ſaps which contain acetous acid in a free ſtate contain no carbonic acid, neither free nor united with a baſe, but that both acids are often combined with theſe two baſes in the ſame ſappy liquor; that all the ſaps contain vegetable matters, which become coloured in

the air, and by the effects of heat; that they all yield ammonia by diſtillation; that muriate and ſulphate of pot-aſh are alſo found in all.

13. It is eaſy to conceive, from the intereſting diſcoveries of the two French chemiſts, that ſap is a very much compounded liquor, in a certain degree comparable with blood, containing a large part of the materials of plants, diſpoſed to form them all, according to the different places which it is deſtined to traverſe, or in which it reſides. I ſhall ſhow hereafter, that a portion of the ſubſtances which it holds in ſolution, proceed from the ſoil itſelf in which the roots are ſituated.

E. *Species and Varieties.*

14. We are yet far from having examined a ſufficient number of ſpecies or varieties of ſaps, to be able to draw general and certain concluſions with reſpect to their comparative properties. Hitherto only the ſaps of the vine, the elm, the birch, the beech, the oak, and the yoke-elm, have been analyzed. The following is what already reſults reſpecting the difference of thoſe liquors, according to the comparative analyſis that has been made of them.

The ſaps of the oak and the beech contain gallic acid and tanin; they cannot at the ſame time contain animal ſubſtance, becauſe this principle would precipitate it. Accordingly, by mixing theſe ſaps with white of egg, with a ſolution of glue, and with a ſolution of the gluten of flour in vinegar; Citizen Vauquelin has obtained a precipitate of tanned animal matter. After having ſeparated this precipitate, the ſupernatant liquor contained gallic acid, acetites of pot-aſh and of lime, and two extracts: the one ſoluble in alcohol; the other mucilaginous, inſoluble in this liquor, and capable of being converted into mucous and oxalic acids by the nitric acid.

The ſaps of the birch and the maple contain a ſufficient quantity of saccharine matter for it to be extracted with advantage, and for their forming a kind of vinous liquid by the fermentation which they are capable of undergoing.

Finally, there are ſeveral ſaps which contain a remarkable quantity of nitrate of pot-aſh.

It would be ſuperfluous here to obſerve, how uſeful and intereſting it would be to analyze the ſaps of different trees; what intereſting reſults might be obtained from this analyſis, for the completion of our chemical knowledge reſpecting the vegetable compounds, and afterwards for vegetable phyſics.

F. *Uſes.*

15. It is not difficult to ſee that the uſe of the ſap in the economy of nature is to ſerve the purpoſes of vegetation by developing the parts of plants, and the formation of the different immediate materials of plants; that this liquid

is

is the principal ſource of all the vegetable liquors, and even of their ſolid materials.

16. Though it cannot be ſaid that the ſaps are real food for man, thoſe which contain ſugar may to a certain degree anſwer this purpoſe. They are uſed for preparing drinks, vinous, ſtrengthening and refreſhing liquors, which are highly eſteemed by phyſicians, and employed in many parts of Germany in the treatment of acute and febrile diſeaſes. Beſides which, the uſe which is made in North America of the ſap of the maple, in order to extract ſugar from it, which affords a ſubſtitute for that of the African or American ſugar-canes, proves that we may at leaſt rank this liquor in the claſs of auxiliary foods.

Addition to the Article on Sap, relative to the expreſſed Juice of Plants.

1. We may rank after the ſap, and even conſider as a ſpecies of this liquid, that which is termed the juice of plants, and which is extracted, either for medicinal uſe in the laboratories of pharmacy, or as a matter uſeful in the arts in ſome manufactories. In fact, theſe ſaps, from whatever plants we may take them, or from whatever freſh vegetable we may extract them, are compoſed in a great meaſure of ſap; for by pounding theſe organized bodies in a mortar, we break and open in all their conti-

nuities the common or ſap-veſſels which are filled with it. The proceſs for obtaining them is extremely ſimple. The freſh, green, and ſucculent plants are chopped ſmall, or pounded in a mortar of marble or wood; the latter is eſpecially preferred when the operation is to be performed upon acid herbs; they are moulded with the hand into a kind of ball, which is forcibly preſſed, or they are incloſed in a piece of linen, which is tied together, and afterwards put into a preſs; ſometimes, in order to cauſe the juice which they contain to flow freely, water is added, particularly when the plants are too dry, or when they are too viſcous.

2. As by this manipulation we obtain juices very much coloured, very turbid, and much charged with the fibrous parenchyma of the plants, which the peſtle or the cutting inſtruments have lacerated in all their points, it is evident that theſe juices are far from being the pure liquid which diſtended their veſſels. They not only contain ſap, but they are alſo mixed with the liquids incloſed in the proper veſſels, the mucilages ſeparated from the utricles and the cortical layers, with fecula or fibrous parts, more or leſs minute, torn away from the texture of the vegetable itſelf. Of theſe different matters thus added to the ſap, ſome, being diſſolved in water, cannot be ſeparated from thoſe which belong to the ſap itſelf, except by chemical proceſſes more or leſs complicated; others, being only diſſeminated

and ſuſpended in the liquid, and conſiſting of ſolid molecules, are much more eaſy to be precipitated from it.

3. The ſeparation of the latter, which deſtroys the tranſparency and purity of the expreſſed juices of plants, is eſpecially recommended in the laboratories of pharmacy, in order to effect what is called defecation: reſt alone is frequently ſufficient to anſwer this purpoſe. When the juice is very fluid, the fibrous particles of the fecula approach to each other, collect together, depoſit themſelves in the form of flakes more or leſs green at the bottom of the liquid, which only requires to be decanted in order to have it ſufficiently pure. This ſimple proceſs, it is true, can only be uſed in thoſe caſes where the juice is not ſuſceptible of ſpontaneous change, where it contains no volatile and odorous principle which it is neceſſary to preſerve, in order that it may enjoy all its medicinal properties: for the ſpontaneous precipitation, and the complete depoſition of the fecula, frequently require ſeveral hours; and this time is ſometimes ſufficient for an interior motion or ſome alteration to eſtabliſh itſelf in the juices, eſpecially when the temperature is elevated above fifteen degrees in the atmoſphere.

4. Sometimes filtration through paper without ſize is had recourſe to, in order to ſeparate the fecula from the juices. This proceſs is practiſed only for the moſt fluid and lighteſt juices, that are required to be purified quickly;

ſuch as thoſe of houſe-leek, purſlain, lettuce, ſuccory, &c. In other circumſtances, eſpecially when we have to treat juices a little viſcid, mucilaginous, thick, and containing nothing volatile, as the juices of borage, bugloſs, pellitory, or nettles, we mix them with a little white of egg and water, then ſtir them, cauſe them to boil for a moment, and filtrate them when they have cooled. The albumen, as it coagulates, forms a reticular ſubſtance, which, in its aſcent, detains and ſeparates all the feculent particles that troubled the liquid. But the heat of the ebullition gives them a much deeper colour than they had before, and alters them ſenſibly; ſo that this is not merely a defecating, but an actually decompoſing proceſs.

5. There are ſome juices whoſe alterability is ſo great with reſpect to the odorous matter which they contain, and which it is neceſſary to preſerve for the medicinal uſe for which they are deſtined, that we have been obliged to ſeek means of ſeparating the fecula with ſufficient celerity not to leave them time to become altered, and gentle enough not to change or affect their intimate nature. Such is the proceſs employed for defecating the juices of creſſes, cochlearia, beccabenga, and all the antiſcorbutic juices which have an acrid and pungent odour. It conſiſts in putting them into a matraſs or bottle, the mouth of which is covered with a piece of wet parchment perforated with ſeveral punctures with

a pin, plunging this bottle into another veſſel filled with boiling water, and ſuffering it to remain for ſome minutes in this bath; we ſoon ſee its fecula collect in concrete flakes, which gradually depoſit themſelves at the bottom; we then filtrate the liquid, which is found to have loſt nothing of its ſmell or of its properties. This proceſs is founded upon the nature of the fecula, which appears to approach to that of albumen or glutinous matter, and as ſuch to be coagulated by the action of the fire, and afterwards ceaſe to be capable of being ſuſpended in the liquid.

Laſtly, another means is ſometimes employed, in order to defecate the juices of plants, by adding to them vegetable acids, lemon-juice, vinegar, ſometimes even wine, and eſpecially white wine: this practice is eſpecially recommended in ſome foreign diſpenſaries. Indeed, it is only propoſed for the antiſcorbutic juices, with which we thus join a ſubſtance that can only augment their energy, and add to their medicinal virtues; it is alſo founded upon the albuminous and coagulable property of the feculent matter. It is very evident that if theſe juices contain glutinous matter, this principle muſt remain in part diſſolved in the defecating acid.

7. The purified or depurated juices of plants have great analogy with ſap; like it, they frequently contain a free acid, and almoſt always acetites, either of pot-aſh, or of lime; like it,

they are coloured by the action of the fire and the air; like it, they precipitate coloured flakes by the addition of oxigenated muriatic acid; like it, finally, they yield by evaporation, red or brown extractive matters. They, however, differ from it in the circumſtance that ſaccharine matter is rarely found in them, and never tanin or gallic acid. In general, the two latter materials are only met with in the ſaps of the trees; they have the moſt intimate relation with the ligneous ſubſtance; they conſtitute either the ſource or the depoſitary of this ſolid ſubſtance. The juices of plants differ alſo from ſap in the circumſtance that we frequently find in them a greater or leſs quantity of gummy mucilage, which exiſts but very rarely or never in the latter; and we ſee that theſe differences depend either upon thoſe of the young, ſucculent, herbaceous plants, from which the juices are expreſſed, or upon the manner itſelf that is employed for obtaining them, the violent preſſure which is practiſed. Citizen Vauquelin has lately found the malate of lime to exiſt in conſiderable abundance in the juices of the houſeleek (*ſempervivum tectorum*), and of ſeveral ſpecies of *ſedum*.

8. In a chemical point of view, the expreſſed juices belong much more nearly than the ſaps to the hiſtory of the extract, or extractive in general. When we evaporate the former liquids by the action of the fire, in order to obtain what are termed *inſpiſſated juices*, ſuch as the

juice of borage, of the elaterium or wild gourd, the juice of the acacia, that of hypociſtus, of ſloes, opium, &c. we actually prepare a kind of extracts or extractive mixtures, conſiderably reſembling thoſe that are obtained by the action of water upon the dry vegetable ſubſtances. I ſhall ſpeak of them again under this relation in one of the ſubſequent articles.

ARTICLE V.

Of the ſecond of the immediate Materials of Vegetables, of the Mucus, or the Mucilages and Gums.

A. *Seat.*

1. MUCUS, mucous ſubſtance, or mucilage, ſo eaſily diſtinguiſhable by its viſcoſity, its thick and gluey conſiſtence, its faint or inſipid taſte is found in many vegetable parts different from each other: it is one of the moſt diffuſed of the immediate materials of vegetables, and which the work of vegetation ſeems to form the moſt eaſily and frequently. It is known in all the organs of plants, when by pounding them their particles adhere to one another as it were, in a pulp, when all the ſubſtances that are brought into contact with them, ſtick and adhere to them, when they join with this firſt property an inſipidity, or faint taſte more or leſs peculiar, and an inodorous quality.

2. It is found in a great many roots, ſuch as thoſe of the mallows, conſolida, the lily, &c. and in general in thoſe of young plants, in ſuch as do not naturally become ligneous, or thoſe which only become ſo very late. It exiſts in the ſtalks, and eſpecially under the epidermis, and between the laſt cortical layers, which it moiſtens, through which it frequently forms itſelf a vent, in order to run out, as we ſo often ſee in the fruit-trees, eſpecially in thoſe that produce ſtone-fruits. It is alſo found in the leaves of a great number of vegetables, almoſt at all periods of vegetation, and in all towards the commencement of their opening and unfolding themſelves. This we may aſcertain at this period, by cruſhing between the fingers the delicate texture of the leaves, which ſtrongly adheres to the ſkin; it frequently accompanies the pulpy or parenchymatous texture of the fruits, always the integuments of the ſeeds, ſometimes the exterior, ſometimes the interior. Before the cotyledons are formed, and have become dry and farinaceous, they exiſt under the gelatinous, tranſparent, and viſcous form of a mucilaginous ſubſtance.

3. Very frequently the mucus is intimately mixed, or even combined with ſome other immediate principles of vegetables, eſpecially with ſugar and the acids, as we find to be the caſe in moſt of the fruits from which the juice is eaſily extracted; ſometimes with the amilaceous fecula or ſtarch, with the fixed oils,

with the reſins, or the gum-reſins. When it is alone and inſulated, it frequently forms a real plethora in the different organs of the vegetables, and particularly between the external laminæ of the cortical layers below the epidermis, eſpecially towards the extremities of the branches, of the petioles, of the peduncules of the flowers and fruit; it is moſt frequently at thoſe points where there are a great number of interruptions and fiſſures in the continuity of the epidermis, that the mucus iſſues and runs out on the ſurface of trees, which frequently contain a large quantity of it.

B. *Extraction.*

4. When the ſuper-abundance of the mucous juice violently diſtends the veſſels of trees (for the ſame phenomenon is not obſerved in the herbaceous plants) thoſe veſſels become ruptured, and the mucilage, more or leſs thick, viſcous, and gluey, iſſues in drops which ſpeedily dry in the air. Then the ſurface of theſe trees, and eſpecially the points of the inſertion of the branches, the twigs, the petioles, the leaves, the peduncles, the fruits, and the fiſſures which are ſometimes formed upon them, become covered with theſe drops of mucus, which gradually accumulating and drying in the air, give riſe to tears, tranſparent round irregular bodies, ſometimes to ſtalactiform elongations, to a kind of blades or

ribbands, ſmooth or ſtriated, white, yellowiſh, reddiſh or brown, which are known and collected by the name of *gums*. Thus the traveller, who journeys through the interior of Africa, finds every where in his courſe the tears of the gum Arabic, which hang from the twigs of the acacia, or *mimoſa nilotica*, which grows in abundance in thoſe countries. Thus in our orchards and gardens, the apricot, the peach, the plumb, the cherry, the almond-trees become covered at the beginning of the ſummer with gummy tears, which are ſeparated from them, and are known in commerce by the name of gum of the country *(gummi noſtras)*.

5. When the gummiferous trees, eſpecially the old, are ſurcharged with this mucous ſubſtance which ſwells their veſſels, longitudinal orifices, in the direction of the axis of the trees, are ſometimes made in their bark with ſucceſs, for their preſervation and health. In this caſe, the gummy juice iſſues out more or leſs abundantly by theſe inciſions, and may be collected in large quantities. As nature furniſhes it in ſufficient abundance for all the uſes to which this ſubſtance is appropriated, this operation is not performed for the purpoſe of obtaining it, but merely for the relief of the trees.

6. When the mucus, in the form of a thick and viſcous liquid, is intimately or profoundly incloſed in the organs of vegetables, as in the roots, &c. when it is applied in dry and poliſhed layers to the ſurface of the ſhining or gloſſy

ſeeds, ſuch as thoſe of flax; when it exiſts in thin, but not dry layers, under this integument of the ſeeds, as in all thoſe of the cucurbitaceous plants, the pippin-fruits, the quince, &c. we can neither extract it by trituration nor by preſſure. In this caſe we dilute or even diſſolve it with the aid of hot or boiling water; and in this ſtate it is more eſpecially called *mucilage.* Thus the juices of ſome young mucous and gluey leaves, when they have been cruſhed and reduced into a pulp, eſpecially ſuch as thoſe of borage, of bugloſs, of ſcabioſa, &c. cannot eaſily run out, without water being added previous to their expreſſion, on account of the large quantity of mucilage which accompanies their ſap, and which we are obliged to extract together with it.

7. The mucilage frequently being combined with a vegetable acid, and diſſolved or rendered fluid by this acid, runs out together with it, and affords a ſour juice, poſſeſſing a greater or leſs degree of viſcoſity. Such are the juices of the lemon, the orange, the currant, the ſtrawberry, the raſpberry, the cherry, the plumb, the peach, the apple, the barberry, the ſervice, the grape, &c. &c. we unite their two conſtituent materials ſtill more intimately together, prevent their ſeparation, and impede their alteration, by diſſolving in them a ſufficient quantity of ſugar, as is done in the preparations known by the name of *conſerves.* But if, inſtead of following this practice, we leave theſe juices to themſelves after

having extracted them from the fruits, at the end of ſome hours, and eſpecially with the contact of the air, they depoſit the mucilage which they contain in a gelatinous form; we may ſeparate them by placing theſe liquids which have become thick by depoſition, upon a cloſe and fine ſieve, which ſuffers the more liquid acid part gradually to run out, and detains the mucous juice. This is waſhed with a little pure water, in order to ſeparate the portion of acid which it ſtill contains. Frequently it retains a ſmall quantity of colouring matter, which gives it a yellowiſh, fawn, or roſe-coloured tinge. By drying, it aſſumes more colour, diminiſhes in its volume, preſerves its tranſparence, and becomes dry and brittle like a real gum.

8. There are ſome caſes in which the mucus accompanies the oils; thoſe that are termed fixed are particularly impregnated with it: it then forms what Scheele terms the *mild principle* of the oils. It is not ſeparated from them without much difficulty; ſometimes it is ſpontaneouſly precipitated from them by reſt, and preſents itſelf at the bottom of theſe liquids as a flaky depoſition. It always impedes their combuſtibility, and contributes to form the knobs on the wicks of lamps; a more or leſs abundant portion of it is depoſited when we heat theſe oils, and a ſort of precipitate is formed, which impairs their tranſparency, and renders them viſcid. It is alſo ſeparated from theſe inflammable bodies by the action of ſeveral re-agents, and

eſpecially by that of the metallic oxides, as Scheele has obſerved, and as I ſhall ſhow in the hiſtory of the fixed oils.

C. *Phyſical Properties.*

9. The mucus exiſts in three principal ſtates, either in or out of the vegetables. It is ſolid or concrete and friable, and in fragments or pieces more or leſs large; it is almoſt always ſpheroidal on the outſide of the trees; it is either ſprinkled in the form of powder, or ſpread in thin layers upon the ſurface of a great number of ſeeds: laſtly, it is in the ſtate of a viſcid, gluey, thick liquid in the roots, the ſtalks, the internal part of the ſeeds. Its liquid ſtate varies greatly in denſity, according to a multitude of circumſtances, which tend to thicken or to diſſolve it, eſpecially according to the dryneſs or moiſture of the weather, according to the proportion of water which the plants are capable of abſorbing.

10. The viſcid nature of the ſoft mucous ſubſtance, the kind of glutinous or agglutinating conſiſtence which it poſſeſſes without being elaſtic, the tendency to adhere which ſubſiſts between its own particles, and communicates itſelf to the different ſurfaces between which it is placed, joined with the brittle and pulverizable property which it poſſeſſes when ſufficiently dry and gummy, prove that it owes the firſt of thoſe characters to the adheſion

which its particles contract with water, and their attraction for this liquid.

11. Mucus when very pure is colourleſs. It is clear and tranſparent like water. It never becomes coloured, except in conſequence of its having undergone a firſt degree of alteration in its intimate compoſition, or being mixed with ſome foreign ſubſtance of a colouring nature. It has no taſte properly ſo-called, it is only ſweetiſh and inſipid. Every taſte beſides this, whether aſtringent or ſaccharine, or bitter, proceeds from ſome foreign ſubſtance aſſociated with it. It is alſo perfectly inodorous: when, reduced into powder or into vapour by the means of boiling water, it is introduced into the noſtrils, it excites only a very ſlight impreſſion, which would ſcarcely be ſufficient to apprize us of its preſence without the aid of the other ſenſes, of the ſight or the touch. Its ſpecific gravity, from the pureſt to the moſt mixed gum, is to that of water, as 13,161, or 14,817 to 10,000.

D. *Chemical Properties.*

12. Mucus, expoſed dry or in the ſtate of gum, to an open fire, or with the contact of the air, is fuſed, ſwells, becomes yellow, red, and brown; is reduced to coal, augmenting greatly in its volume, and exhales ſucceſſively, during this alteration, an aqueous vapour, a more denſe ſmoke of a pungent ſour ſmell, which is not unpleaſant; it produces only ſome light

flames: at the termination of this action it leaves a light and very voluminous coal. When diſtilled in an apparatus properly diſpoſed and provided with pneumato-chemical tubes, it affords water, a reddiſh acid liquor, ſome drops of brown oil, carbonic acid gas, a little carbonated hidrogen gas, and a coal much more bulky and of a different form from the gum, of a ſingle piece when this has been introduced in powder or in ſmall fragments into the crucible. The water diſengaged has been compoſed in a direct way by the combination of the hidrogen and the oxigen of the gum, and was not contained in this body. The oil, which is in very ſmall quantity, is the product of a portion of carbon and hidrogen, united and ſublimed together; the carbonic acid gas proceeds from a portion of the carbon burned ſeparately by the oxigen at a high temperature, and perhaps even from a part of the water already formed, decompoſed by the carbon, ſet free, and brought to a red heat: which ſeems to be proved by the carbonated hidrogen gas which accompanies it, and which, like the firſt gas, is not developed, but at laſt, and when the action of the fire is the ſtrongeſt. The coal, which forms about a fifth part of the gum, and which remains in the retort, is light, porous, eaſy to be burned; it yields but very little aſhes, in which are found ſome traces of pot-aſh, a ſmall quantity of carbonate, and of phoſphate of lime.

13. With reſpect to the acid, one of the new

and moſt remarkable products of the decompoſition of mucus, it is a compound formed at the expenſe of a portion of the carbon, the hidrogen, and the oxigen of the gum; a compound which was not contained in this natural inſipid product, that does not redden the blue colours. This acid is a creation of the fire. As it will ſeveral times preſent itſelf in the examination of the immediate materials of vegetables, and as it is not otherwiſe found amongſt the natural products of plants, it is neceſſary here to explain what is known of its properties or characters. The firſt chemiſts who have mentioned it knew it only by the name of ſpirit, or acid phlegm of gum; and Citizen Guyton termed it ſirupous acid, becauſe it is alſo a product of the diſtillation of ſyrup, and as he had obtained it in conſiderable abundance from diſtilled ſugar. Laſtly, in order to generalize its nature, its formation, and its origin, it has been termed pyromucous acid. He has not yet ſtudied all its combinations: however, what has already been collected reſpecting its properties is ſufficient to diſtinguiſh and characterize it. Chemiſts have erroneouſly believed it to exiſt ready formed in the gums; they have admitted it in a ſaponaceous combination with oil, and nevertheleſs there exiſts as little oil as acid ready formed in theſe vegetable compounds.

14. The pyromucous acid is always liquid; it is neither more nor leſs volatile than water;

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it does not abandon it when it is diſtilled; we can neither obtain it in the gaſeous nor in the ſolid form. It has a pungent, ſour, and empyreumatic taſte; it has a ſmell analogous to that of radiſhes, or of roaſted bitter almonds: in this reſpect it in ſome meaſure reſembles the pruſſic acid. At a high temperature it is decompoſed into carbonic acid and water; it always leaves a coaly ſtain when it is diſtilled in a retort. When we expoſe it to the froſt, it becomes concentrated on account of the portion of water which ſeparates from it. It produces upon the ſkin an orange-coloured or reddiſh ſtain, which diſappears only with the cuticle. With lime it forms a calcareous pyromucite of conſiderable ſolubility. Its ſaline combinations are not known; we only know that they differ from all the others. It diſengages the carbonic acid from all its baſes, and produces a lively efferveſcence with all the carbonates. It attacks neither platina, nor gold, nor ſilver, nor mercury; it corrodes and oxides copper, iron, lead, and tin; it cryſtallizes with the oxide of lead and the oxide of iron. The order of its elective attractions, according to Citizen Guyton, is the following: pot-aſh, ſoda, barites, lime, magneſia, ammonia, alumine, the metallic oxides, water and alcohol. We ſee from this ſhort expoſition, that the properties of this pyromucous acid are as yet ſcarcely known, and that what has been determined concerning them is merely ſufficient to ſhow that it differs from all thoſe that have hitherto been diſcovered; no uſe is made of it.

15. The gums are abſolutely inalterable by the air; the mucilage only thickens and becomes gummy. Water eaſily diſſolves the mucus, which gives it a great degree of viſcidity, as every one knows. Heat greatly aids the action of the water, and enables it to diſſolve more quickly a larger quantity of gum; when too ſtrong or too long continued it evaporates it, and at laſt reduces the mucilage to the dry and gummy ſtate. Mucus diſſolved in water is not altered; of all the immediate materials it is that which moſt reſiſts ſpontaneous alteration.

16. The weak or diluted acids only diſſolve mucus without alteration. The concentrated ſulphuric acid, by its ſpontaneous action upon this body, decompoſes it, converts it into water without itſelf experiencing any change. It thus ſets its carbon free, and changes part of it into acetous acid. The ſame is the caſe with the muriatic acid, which reduces it to coal in the courſe of time. The oxigenated muriatic acid acidifies it; but it is the nitric acid that acts the moſt powerfully upon it.

17. The nitric acid, ſlightly heated in the proportion of two parts upon one of mucus, till a ſmall quantity of nitrous gas and of carbonic acid is diſengaged, afterwards throws down by the cooling of the whole liquid and diſſolved maſs, a white, ſlightly acid powder, which Scheele has called acid of ſugar of milk, the

ſachlactic acid of the methodical nomenclature, as it has been eſpecially obtained with the ſugar of milk. As it is not peculiar to the latter ſubſtance, and as it is prepared with all the mucilages, I term it mucous acid.

It is in the form of a white powder, a little granulated, of a ſlightly ſour taſte; it is decompoſed by the action of fire, yields an acid phlegm which cryſtallizes in needles by reſt, a ſmall quantity of oil of a blood-red colour, acrid and cauſtic, carbonic acid gas, and carbonated hidrogen gas: it leaves a great deal of coal; a part appears to ſublime in brown needles or plates of a ſmell analogous to that of the benzoic acid, or perhaps it alſo forms an acid modified differently from what it was at firſt, as the tartareous acid alſo does.

This pulverulent mucous acid has very little ſolubility in water, and that liquid, when boiling, hardly takes up from it more than two or three hundredths of its weight; boiling water does not take up one half more, and nevertheleſs it is depoſited by cooling in brilliant filaments which become white in the air. At the heat of boiling water it decompoſes the carbonates. It forms with pot-aſh a ſalt ſoluble in eight parts of hot water, cryſtallizable by refrigeration. The mucite of ſoda is equally cryſtallizable, and requires only five parts of water to diſſolve it: theſe two ſalts are much more ſoluble by an exceſs of their acid or of their baſes. The mucite of ammonia is little known; it loſes its baſe by the action of heat. We do not yet know the combination of the mucous acid with the other baſes; we only know that the mucites of barites of lime and of magneſia are nearly inſoluble. This acid decompoſes the nitrate and the muriate of lime, as well as the muriate of barites.

The mucous acid acts but very feebly upon the metals; it appears to form with their oxides ſalts of little ſolubility. It precipitates the nitrates of ſilver, of lead, and of mercury.

The compoſition and the proportions of its principles have not yet been determined; we only perceive that it contains a large quantity of carbon; and that in proportion as it is formed by the change of the equilibrium of the component parts of the gums that yield the moſt of it, a change effected by the action of the nitric acid, the remaining part of this body is ſenſibly leſs carbonated. Citizen Vauquelin and myſelf have found, in our experiments upon this object, that 100 parts of gum yield from 0,14 to 0,26 of mucous acid; that the nitric acid does not change the nature of this acid; that we may cauſe it to boil for a long time without its being altered; that it is depoſited after cooling in the conſtant form of a white powder. None of our experiments have ſhown us, as Mr. Hermſtaedt has ſuppoſed, that this acid is an oxalate of lime combined with a fatty matter: all our reſearches, on the contrary, have ſhown us, that it is a particular acid formed in the firſt period of the action of the nitric acid upon the inſipid gummy and mucilaginous vegetable ſubſtances. According to this, it is very evident that the name of ſachlactic acid does not ſuit it.

18. With reſpect to the nitric acid, after its firſt re-action upon the mucus has converted it in part into the acid, which I have juſt deſcribed, if we examine the liquor, we find that it contains a ſecond acid, entirely different from the firſt, of a denſe liquid conſiſtence, very ſour, very ſoluble, which Scheele firſt obſerved to be formed by the action of the nitric acid, and which he termed malic acid. This ſecond acid, which holds the middle place, with reſpect to the period of its formation, between the mucous and the oxalic, does not exiſt but when the nitric acid has not been boiled for a long time, or when it has not been employed in a large quantity, or too much concentrated upon the gum. It is not certainly obtained, except after the firſt efferveſcence which I have indicated: it exiſts alſo in the mother water of the oxalic acid. It is eaſily converted into the latter acid, by the ſucceſſive action of the nitric acid. Citizen Vauquelin and myſelf had at firſt believed that this acid was different from the malic: I propoſe to term it the *oxalous* acid, becauſe it precedes the oxalic acid in its formation, and as it appears to me to differ from it only by a little more combuſtible matter, and eſpecially carbon, in its radical. The following are the characteriſtic properties which we have found in it. Its taſte has much analogy with that of lemon juice; it has no colour, but it eaſily becomes red and

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brown by the progreſs of evaporation. It is eaſily decompoſed and reduced into coal by the action of the fire. It is very ſoluble in water, and cannot aſſume the ſolid and cryſtalline form. It eaſily diſſolves in alcohol, and does not cryſtallize even by the evaporation of this volatile ſolvent. It precipitates lime-water, and forms with it a calcareous ſalt, ſoluble in an exceſs of its acid, a property which already diſtinguiſhes it from the oxalic acid, the combination of which with lime does not diſſolve in its own acid. This earthy ſalt diſſolves abundantly in boiling water, forms a ſolution of a reddiſh-brown colour, which precipitates by cooling in the form of ductile, and as it were reſinous flakes; theſe flakes, again become brittle by deſiccation. With barites it conſtitutes a ſalt that has little ſolubility, except in its own acid. Theſe ſalts are decompoſed by the ſulphuric acid. The oxalic acid itſelf alſo decompoſes the calcareous ſalt deſcribed, a proof that the acid indicated is very different from the firſt. One of its moſt diſtinct and moſt remarkable properties is, that the nitric acid and the oxigenated muriatic acid ſpeedily convert it into oxalic acid. In this converſion nitrous gas and carbonic acid are diſengaged: it takes place when we continue to heat nitric acid upon the gum. By this we ſee that its formation preceding that of the oxalic acid, and this ſucceeding it only by the fixation of a larger proportion of oxigen, it is to the oxalic acid nearly what the ſulphureous acid is to the ſulphuric, excepting that it loſes alſo a portion of its radical. But by comparing theſe properties with thoſe of the malic acid, we found it to be perfectly identical with that acid.

19. What is moſt ſingular and moſt remarkable in the formation of the mucous and the malic acids, in gum treated by the nitric acid, is their almoſt ſimultaneous creation. In fact, it is very difficult to conceive why the nature of this body is not equally changed throughout the whole of its maſs; why a part becomes mucous acid, and another part malic acid at the ſame time; why it thus divides itſelf into two different ſubſtances, and by what aſtoniſhing mechaniſm, by what complicated attraction theſe two compounds are formed at the ſame time. For the reſt, this character of being divided into two, and ſometimes three products, is found in moſt of the organic materials altered or decompóſed by any re-agent, by whatever cauſe this may be. From 100 parts of gum Arabic we have generally obtained 0,24 of malic acid.

20. When, inſtead of ſtopping the action of the nitric acid after the firſt effervеſcence, or at the period when the malic acid is formed, we continue the application of the heat, and diſengage more nitrous gas and carbonic acid; the laſt mentioned and ſecond acid formed, paſſes into the ſtate of cryſtallizable oxalic acid, decompoſing all the calcareous ſalts, on account of

its great attraction for lime. As this latter acid exiſts ready formed in many vegetables, as I ſhall conſider it more particularly in one of the ſubſequent articles, amongſt the immediate materials of vegetables, I only indicate it in this place. I ſhall only add to this general indication, that after having made it to cryſtallize, there remains in the laſt liquor, in the kind of mother-water, which no longer cryſtallizes, a portion of malic acid above deſcribed; but that, by treating the laſt mentioned liquor again with a new doſe of nitric acid, we may change it entirely into oxalic acid.

21. One of the moſt aſtoniſhing facts amongſt the diſcoveries of modern chemiſtry is, the converſion of gum, or mucilage, into five different acids, according to the manner in which it is treated. In fact, fire develops in it pyromucous acid; the action of the ſulphuric and muriatic acids forms acetous acid; that of the nitric acid conſtantly changes it, in part, into mucous acid, and afterwards, in part, into malic acid, if we do not puſh its action far, or if we augment it into oxalic acid. Though analogous phenomena preſent themſelves alſo in ſeveral other immediate materials of vegetables, of which I ſhall ſpeak hereafter, the gum, which preſents them the moſt eaſily and the moſt conſtantly, announces, as we ſee, in its nature and compoſition, changes which the pneumatic doctrine alone will be able to determine; for it is evident, from what has hitherto been ſaid,

that all the cauſes of theſe changes have not been exactly diſcovered or appreciated.

22. It is to the ſame diſpoſition to change its nature and yield products of very various kinds, that we are to aſcribe an effect obſerved by Mr. Woulfe, and indicated in the *Journal de Phyſique*, 1788. He obſerved, that when gums were diſtilled with fixed alkali, much more oil was obtained than when they were heated by themſelves, and that they ſwelled conſiderably during this operation. This phenomenon depends only upon the attraction which the alkali exerciſes upon the pyromucous acid, the manner in which it fixes and retains it, and that in which it determines its decompoſition by the action of a violent fire. The carbon and the oxigen then unite together, and the hidrogen united with a portion of carbon, forms oil which is diſengaged, while alone it yields a large quantity of water, and ſcarce any oil: in the ſame manner the acetous acid, diſtilled alone, is entirely volatilized, but yields oil when it is heated in union with the alkalis.

23. There is no well-determined action between mucus and the ſalts. It is eaſy to imagine that when it is ſtrongly heated with the ſulphates, its hidrogen and its carbon muſt decompoſe theſe ſalts, and convert them into ſulphurets; that the nitrates muſt alſo burn it, deſtroy it completely, and preſent, after this combuſtion, only its moſt fixed parts; that thus the nitrate of pot-aſh may be employed in order to

aſcertain the quantity of earth and the fixed ſalts contained in this matter. The ſuper-oxigenated muriate produces this effect in a ſtill more marked manner; it inflames the mucus, and burns it by mere preſſure. A mixture of two parts of this ſalt and one part of gum, in the ſtate of fine powder, detonates by percuſſion, and produces as much noiſe and even more than that of the ſimple combuſtible bodies. There is reaſon to believe that this decompoſition may hereafter ſerve to determine the proportion of the firſt component principles of mucus, as well thoſe of the other immediate materials of vegetables.

24. The metallic oxides moſt charged with oxigen, and adhering leaſt to this principle, may likewiſe ſerve to decompoſe mucus by burning it, like thoſe of ſilver and mercury; this action has not been ſufficiently examined, nor has by any means all the advantage been derived from them which they may afford for this kind of analyſis. The ſame is the caſe with the metallic ſolutions; it has been remarked that they produce a precipitate in the ſolutions of gums; that this flaky and viſcous precipitate carries with it the oxides, and becomes coloured with different tinges, according to the nature of theſe; that in general theſe oxides approach to the metallic ſtate. But it has not yet been determined, with exactneſs, what takes place in theſe precipitations, what kind of attraction the mucus experiences, whether it is changed at the ſame time

as it is precipitated; or whether the change, ſuppoſing it to take place, does not happen only a more or leſs long time after the precipitation.

25 From all the chemical phenomena which mucus preſents with the different agents of which I have juſt given an account, and eſpecially from the compariſon of the action of fire, and of the acids, it muſt be concluded that this body is a kind of oxide of hidrogen and carbon, in a ſtate of triple combination, ſufficiently ſolid not to be deſtroyed but by a violent action, which remains a long time in a ſtate of equilibrium, and which is one of the firſt formed by vegetation, which coſts the leaſt, as it were to the vegetable organization, and is conſequently found in moſt of the organs of plants. Citizen Vauquelin and myſelf have found, in our inveſtigations of the vegetable ſubſtances, that 100 parts of gum contain 23,08 of carbon, 11,54 of hidrogen, and 65,38 of oxigen.

E. *Species or Varieties of Mucus.*

26. Three ſpecies of gum employed in different uſes are eſpecially diſtinguiſhed, the gum of the country, gum Arabic, and gum tragacanth.

A. The gum of the country flows from the apricot, the plum, the cherry, the peach, the almond-tree, &c. and in general from all the ſtone-fruit trees. It is white, yellow, or reddiſh;

diſh; and when it is well choſen it may be uſed in place of gum Arabic, over which it has the advantage of being cheaper. I have collected upon the bark of the elm a juice of an orange or red colour, in concrete round tears, of an inſipid taſte, ſoluble in water, and forming a viſcous ſolution; it is a gummy matter, which is not ſufficiently abundant to be collected with advantage.

B. The gum Arabic flows from the acacia, the ſame which forms the extractive juice inſpiſſated by the fire; this tree, termed *mimoſa nilotica*, is very abundant in Egypt, in Arabia, upon the banks of the Nile, and in a great number of places in Africa in general. The gum hangs to the tree in maſſes roundiſh, irregular, tranſparent, white, yellow, or reddiſh, frequently furrowed, ſometimes twiſted. The fineſt is the moſt colourleſs and limpid: and is uſed as food by the inhabitants of the country. It is ſometimes called in commerce *Gum of Senegal*: the tears are ſeparated according to their beauty and their purity, in order to diſtinguiſh the different qualities.

C. Gum tragacanth is eſpecially obtained from the ſhrub ſo abundant in Crete, termed *adragant*, *aſtragalus tragacantha* of Linnæus It differs from the two preceding in its form; it is in ribbands, or in plates, or in blades contorted, ſtriated, canulated; of an opaque white colour: it is alſo found in ſmall tears of the ſame colour. Its ſolution is much more difficult and more viſcid than that of the gum Arabic, it always contains mucilaginous filaments, or flakes; it is employed as more pure and more uſeful than the latter.

27. Amongſt the numerpus plants which contain the mucous juce, either in a gluey or pulverent ſtate, the roots of the mallow, and the bulbs of the lilly, the ſeed of flax, of the quince, are chiefly choſen for extracting the mucilages in common uſe; they are put to macerate in hot water, and thus are formed viſcous, gluey liquids, which ſupply the place of the gums properly ſo called, and which may even be brought to the gummy ſtate by deſiccation. Every country has beſides ſuch a great number of plants which may furniſh mucilages by their maceration in water, that it would be difficult, and uſeleſs alſo, here to preſent their enumeration.

F. *Uses.*

28. Mucus forms in general one of the vegetable materials which nature has beſt diſpoſed to ſerve as nutriment to animals. I have obſerved, that the Africans live upon the gum of the acacia. I ſhall only obſerve, that none but ſtrong and vigorous ſtomachs can eaſily digeſt this inſipid and viſcid juice, and convert it with facility into chyle. An European, who travels in countries where gum is produced, ought not to make uſe of it without ſome kind of ſeaſoning

ing, and much precaution: for the ſame reaſon the food beſt appropriated to man, amongſt the vegetable matters, is a mixture or a combination of mucous juice and ſugar.

29. In the art of healing, all the gums and all the mucilages are employed with great ſucceſs as emollients, relaxing, ſtrengthening, for quieting irritation, inflammatory heat, and pain; their chief uſe is in topical or external applications to painful inflamed tumors, which ſhow ſigns of commencing reſolution or ſuppuration. This is the reaſon why the mucilages of lint-ſeed, quince-ſeed, mallows, the lily-root, are made to enter into the mixtures of cataplaſms, that are termed ſedative, reſolvent, or emollient.

30. In the arts much uſe is made of gums or mucilages, to give conſiſtence to ſlight piece-goods, and to the colours which are applied over them, and ſometimes to glue or cauſe the ſurfaces of theſe bodies to adhere together. Paper and cloths are ſized by the ſolution of gums. They are employed in order to give body and gloſs to felts, ribbands, and taffetas. Stuffs dipped in gum-water aſſume a tranſient gloſs, and luſtre, which is very quickly deſtroyed by the contact of water. It is alſo made the baſe of the blacking for ſhoes and boots. Gum enters into the fabrication of ink. In a word, the gums and mucilages are very uſeful in domeſtic and manufacturing economy.

ARTICLE VI.

Of the third of the immediate Materials of Vegetables, the Saccharine Mucous Subſtance, or Sugar.

A. *Seat.*

1. THOUGH ſome chemiſts have nearly confounded mucilage and ſugar with each other, and though the latter ſubſtance has been called pretty generally *ſaccharine mucous matter*; though in fact the ſaccharine has great relation with the mucous matter, it is no leſs certain that there exiſts between theſe two ſubſtances certain differences ſo eſſential that it is impoſſible to confound them, and that render it neceſſary to treat of them ſeparately. Sugar, or the ſaccharine matter exiſts in abundance in vegetables. It may even be ſaid, that there is ſcarcely any part of plants which is wholly deprived of it: but we ought here to ſpeak only of thoſe which contain a ſufficient quantity of it for it to be very perceptible by its taſte, for it to be impoſſible to doubt of its preſence, and for this part to be frequently even employed inſtead of ſugar, or ſugar to be extracted from it more or leſs pure.

2. This ſubſtance is found very frequently in roots. Beſides the well-known ſaccharine nature of liquorice, ſugar exiſts alſo in ſufficient abundance in carrots, parſnips, turnips, potatoes; onions; to be extracted and obtained ſeparately, as was done by Margraff, by ſteeping theſe vegetables in alcohol, which diſſolves the ſugar without affecting the mucilages and the extracts. It is generally known that the ſaccharine ſtate of theſe roots is developed by the action of fire in decoction. It is alſo known that there are ſome of theſe parts which contain it in ſufficient abundance to be fit for uſe as an aliment. Such is that which Sparmann ſo happily diſcovered in the interior of Africa, which ſerved him for food during part of his journey.

3. The ſtems are frequently filled with ſaccharine juice. Beſides the ſap of the birch, and eſpecially that of the maple, from which ſugar is extracted in America, the pith of ſome palm-trees, that of the bamboo, that of various reeds, the ſtalk of maize, and eſpecially that of the *ſaccharum officinale*, contain it more or leſs abundantly. It is the laſt mentioned plant which, having been tranſported from Africa into America, becauſe the moſt abounding in this product, furniſhes all Europe with the ſugar which is conſumed in ſuch large quantities, and has become an article almoſt of the firſt neceſſity to a portion of the inhabitants of this part of the world.

4. There are many vegetables whoſe leaves are ſaccharine, and many of them exſude a thick juice in ſmall drops, which thickens and becomes concrete at their ſurface in the form of ſmall grains or ſaccharine powder. Such is the manna that proceeds from the aſh, the larch, the alhagi. Such is the dew which covers the ſurface of the leaves of the lime, of the elm, and many other trees with a brilliant and ſaccharine varniſh in hot and dry ſeaſons. This excretion is even conſidered as a kind of diſeaſe of the trees. It is certain that the leaves are in general thoſe parts of vegetables which have the leaſt of the ſaccharine taſte; it ſeems even that this juice, when it exiſts in them, is diſplaced out of its natural ſituation, and as it were by an error of place.

5. On the other hand, there is not perhaps a ſingle flower which is entirely deſtitute of ſaccharine juice. A great number poſſeſs even a particular organ, the nectary, in which this juice is accumulated and depoſited under the name of *nectar*. It exiſts there at firſt in thick tranſparent drops: it afterwards becomes thicker, and aſſumes even the granulated and ſolid form. It is this nectar, which is at the ſame time both aromatic and ſaccharine, which the bees collect, and which they convert into honey, a ſubſtance very analogous to ſugar, which the ancients uſed, as the moderns have employed the latter ſubſtance ſince the diſcovery of America. But no flower or leaf contains a ſufficient quan-

tity of ſugar for it to be extracted with advantage.

6. The fruits are one of the parts of vegetables in which the ſaccharine matter is moſt abundant. The juice which fills them, the pulp which is incloſed in them, or the fleſh, the more or leſs ſolid parenchyma which forms their texture, are ſo ſaccharine, that it muſt have occurred to the minds of many men to attempt to extract ſugar from them; and it cannot be doubted that this art may be eſtabliſhed at ſome future period with ſucceſs in hot countries, if the advantage of the cultivation of the ſugar-cane ſhould be loſt or diminiſhed by any cauſe: it is known that plums, apples, and figs more eſpecially, are ſo charged with it, that by drying theſe fruits in a ſtove, a conſiderable quantity ſeparates from all their points in grains or in powder.

7. The ſeeds, on the contrary, are perhaps thoſe vegetable parts which contain the leaſt of the ſaccharine matter: but moſt of them have the very remarkable property of becoming ſaccharine by germination. This phenomenon, which is very ſenſible, eſpecially in the cereal or the graminaceous ſeeds, gives riſe to many arts, eſpecially that of brewing. The formation itſelf, or this converſion of an inſipid or mucous vegetable ſubſtance into ſaccharine matter, is one of the facts which muſt throw the greateſt light upon the difference or the relation of theſe two ſubſtances, as I ſhall ſoon ſhow: it is

analogous to what happens in a particular ſpecies of fermentation, which I ſhall diſtinguiſh hereafter, and to what takes place in the maturation of fruits, in which we cannot fail to recognize the production of ſugar by an intimate action of the vegetable materials.

8. Notwithſtanding this multiplicity of places in which we meet with the ſaccharine matter in vegetables, it is to be remarked that it is no where pure, that it is mixed or combined with mucus, with acid, with different kinds of fecula, with extracts, with colouring matters; in a word, that it is not with this ſubſtance as with gum or mucus, which frequently exiſts inſulated, ſo that it may eaſily be extracted or obtained in a ſeparate ſtate.

B. *Extraction.*

9. It is on account of this mixture or combination with ſo many different matters, and ſometimes with ſeveral together, that in order to obtain ſugar properly ſo called, and in the form known to every one, it is not ſufficient merely to preſs the vegetables which contain the ſaccharine juice of which it forms part; but it is alſo neceſſary to prepare theſe juices by proceſſes more or leſs tedious and expenſive, to purify them, to ſeparate from them the fecula, the mucus, and the colouring matter. Two vegetable ſubſtances, namely the juice or ſap of two or three ſpecies of maple, and that of the ſugar-

cane cultivated in America, *arundo ſacchari-fera*, *ſaccharum officinale*, are thoſe which afford it the moſt abundantly, the moſt pure, and with the leaſt labour; though theſe laborious operations conſtitute an art no leſs complicated than important.

10. In Canada, and in ſome of the ſtates of North America, the ſappy juice of the maple is made to run out by ſeveral holes bored in the tree at different heights. In the ſpring, by placing ſnow at the foot of the trees at the cloſe of the night, the flow of this ſweet ſap through the orifices made in the maple trees, is increaſed by the contraction thus produced. This ſap is boiled in proper veſſels till it has acquired the requiſite conſiſtence to ſuffer the ſugar to cryſtallize by cooling; and though this art has not yet been well deſcribed, which it would be uſeful to multiply and eſtabliſh in all the countries in which the maple is ſo abundant, it is highly probable that the proceſſes of which it conſiſts are ſimilar to thoſe which are practiſed upon the juice of the ſugar-cane.

11. In the South American colonies, in the iſlands where the ſugar-cane is cultivated in great abundance, the ſtem, when ripe and ſufficiently yellow, is cruſhed between cylinders; the juice which runs out is received into an hollow table placed under the cylinders, and termed melaſſes; the cane thus exhauſted is employed as fuel. The ſyrup which is more or leſs rich in ſugar according to the maturity

of the cane, the ſoil in which it has been reared, and the ſtate of the atmoſphere that has prevailed during its vegetation, is put into kettles in which it is boiled with wood-aſhes and lime. The liquor is carefully ſcummed; when it is ſufficiently condenſed, or in the ſtate of ſyrup, it is boiled with lime and alum; it is afterwards poured into a back or *cooler;* it is ſtirred with a wooden ſpatula; the cruſt which forms at its ſurface is broken; it is diſtributed into ſhallow wooden veſſels in order to accelerate its cooling; it is poured ſtill luke-warm into caſks placed upright over a ciſtern, and perforated at the bottom with ſeveral holes ſtopped with canes. The juice concretes like a ſalt that cryſtallizes; and the liquid portion or ſyrup into the ciſtern. The ſugar obtained by this firſt operation is termed moſcovado; it is yellow, ſoft, and as it were fatty.

12. This moſcovado, or raw ſugar, is purified or refined in the ſame places by the following proceſs: it is boiled into a ſyrup with a little water; this ſyrup is poured hot into cones of baked earth, or moulds perforated at their lower extremity with a hole, which at firſt is kept ſtopped. Each of theſe cones is placed inverted upon an earthen pot which receives the open point, and ſerves to keep it in a vertical poſition; the ſyrup is firſt ſtirred in theſe cones, and afterwards is ſuffered to cool and cryſtallize. After it has been left to ſtand for fifteen or ſixteen hours, the perforated point of the cones is opened, and

the portion of the ſugar that has not become concrete is ſuffered to run out in *coarſe ſyrup;* the baſe of the concrete ſugar-loaves is ſcraped; while pulverized ſugar is put in, beaten down, and covered with a layer of clay mixed with water: this water filtrating gradually through the particles of the ſugar-loaf, ſeparates from it the ſoft brown portion, which is more ſoluble than the well-cryſtallized part; this runs out, carrying with it the *fine ſyrup.* This operation of claying is ſeveral times repeated; the whitened loaves are then taken out, they are dried in a ſtove for eight or ten days; they are broken, and reduced into large fragments, which are termed *caſſonades*, and ſent to Europe.

13. This operation, of which I here give only an imperfect ſketch, has not yet been brought to its perfection. Hitherto there have been no able chemiſts who have had the means of occupying themſelves with this ſubject in the iſlands; ſome have juſt began to attend to it, and at periods when it was not in their power to apply the new diſcoveries to this work. It is more than probable that a portion of the ſugar is burned in the boilers in which the ſyrup is boiled, and that the evaporation ought to be performed with leſs fire. What takes place in the boiling is not yet known. Some think that it ſerves to ſeparate a fecula, an extract, and a colouring matter; to this they think that the aſhes and lime contribute; others aſſert, and Bergman was of this opinion, that the active

re-agents ſerve to ſeparate a portion of acid that exiſts ready formed in the cane-juice, or which the fire required for the evaporation has developed in it. Some imagine that it is only a ſimple evaporation and the action of the fire, which on the one hand diminiſh the quantity of the water, and condenſe the particles of the ſugar, and on the other coagulate and ſeparate the fecula from the colouring matter. All this uncertainty cannot be diſſipated, and the operation cannot be known and rectified till men inſtructed in the preſent ſtate of chemiſtry ſhall obſerve and examine this operation, upon the place itſelf, and in all its details. The analyſis of the cane-juice will be an indiſpenſable preliminary of this excellent and uſeful work.

14. In Europe the caſſonades are refined by a proceſs which reſembles the laſt boiling of the ſugar. This refining conſiſts in diſſolving the caſſonade in water charged with lime, and adding to it ox-blood, ſize, or white of egg, in order to clarify it. The liquor is boiled, the fire is afterwards ſlackened, the ſcum carefully removed, the ſyrup concentrated by a briſk fire, and the riſing checked by throwing a little butter upon the liquid. When the boiling is completed, the fire is extinguiſhed; the liquid is poured into earthen moulds, then ſtirred and ſuffered to cool; the hole of the moulds is opened; the baſe of the ſugar-loaves is clayed with wet argil, and this claying is repeated till the water has carried away all the ſyrup. and the ſugar is

ſufficiently white; the loaves are dried in a ſtove heated to 40° of Reaumur: they are left eight days in this ſtove, and afterwards put in paper faſtened with packthread. According to the nature of the caſſonades which we treat, we obtain refined ſugar, pure, and more or leſs white. The theory of this operation is not more advanced than that of the boiling of ſugar, and the obſervations which I have made upon the latter apply equally to the refining proceſs.

C. *Phyſical Properties.*

18. Sugar is not only ſolid like a great number of the immediate materials of vegetables; but it is formed of a great number of cryſtalline grains more or leſs brilliant, and is itſelf capable of aſſuming a regular polyhedral form. When it is made to cryſtallize in the ſtate of ſugar-candy, or when it cryſtallizes in liquors which are ſaturated with it, ſuch as the ſyrups, it is obtained in cuneiform octahedrons, imperfect at their two ſummits, each of which is replaced by a rectangle, or in hexahedral priſms terminated by ſummits of two faces. This property, together with its taſte, have cauſed it to be conſidered as a kind of ſaline ſubſtance, and many chemiſts have conſidered it as holding the middle place between mucilages and eſſential ſalts.

16. On account of its ſaccharine and agreeable taſte, it is diſtinguiſhed and reliſhed by

many animals, and even by the carnivorous; it is ſo peculiar to it, and characterizes it ſo well, that there is only this ſingle ſubſtance amongſt all the products of nature which enjoys it, and it certainly depends upon its kind of combination, and the particular proportion of its principles. Sugar has no kind of odour, though inſects are attracted from a diſtance by its preſence: it is white and tranſparent, or colourleſs.

17. It is one of thoſe natural bodies which poſſeſs the phoſphoric property in the moſt marked manner. When it is rubbed or grated in the dark, it diffuſes luminous ſtreaks extremely brilliant, and which paſs with the rapidity of lightning. It appears that the caloric, expelled from between the particles of this body thus rubbed and evidently compreſſed, is diſengaged with the accelerated motion which gives it the form of light.

18. Every one knows the extreme brittleneſs of ſugar; but it has not yet been ſufficiently noticed that it is capable of varying in a remarkable manner, and that the denſity of this body may have a great number of different ſtates. Sometimes it is very hard, and does not break without difficulty. That which is well cryſtallized and candied has the vitreous fracture; that which has congealed ſpeedily is granulated. We meet with ſpecimens which, in this laſt mentioned ſtate, are very tenacious, and cannot be broken in pieces without difficulty. Other pieces crumble with the greateſt eaſe. The firſt

owes its ſtrong conſiſtence to a rapid cryſtallization, and a great degree of dryneſs. The degree of ſoftneſs in the ſecond depends upon the water which it retains between its particles, or which it has abſorbed.

D. *Chemical Properties.*

19. VERY ſtriking relations ſubſiſt between the chemical properties of mucus and thoſe of ſugar. But, though theſe analogies are ſo ſtrong and ſo multiplied, that chemiſts would frequently be at a loſs to diſtinguiſh the products of the one from the other, yet there are ſome particular characters, ſome phenomena produced by various re-agents, which eſtabliſh differences ſufficiently remarkable. I ſhall rapidly paſs over the ſimilar properties, which I ſhall merely indicate, and ſhall dwell more particularly upon thoſe which eſtabliſh diſtinctions conſiderably marked between theſe two bodies.

20. Under the action of fire, the habitudes of ſugar are little different from thoſe of mucus; when heated in contact with the air, it is fuſed more quickly, it is more ſoftened, and is coloured and decompoſed more ſpeedily than gum is; it alſo exhales a more agreeable and more odorous vapour, and leaves a more ſpongy and more dilated coal than that of mucus. Every one knows that ſugar, treated in this manner, is fuſed, ſwells, and diffuſes a ſtrong and agreeable ſmell, known by the name of *Caramel.* If we do not urge

this decompoſition by an open fire ſo far as to reduce the ſugar to a coal, it remains brown, adheſive, deliqueſcent, of an acrid pungent taſte, a little empyreumatic, and very acid. When diſtilled in a retort carefully and ſlowly, by means of a well-graduated fire, it affords more water than gum, ſtill leſs oil, more pyromucous acid, leſs carbonic acid, and carbonated hidrogen gas; and its coal, which is leſs denſe, lighter, and more eaſy to be incinerated, leaves a little more pot-aſh and lime in its reſidue. Theſe phenomena indicate a larger quantity of oxigen, and in general a proportion ſomewhat different between its primitive principles. This is alſo the true cauſe of all the different gradations that will be deſcribed in its properties.

21. Sugar is no leſs unalterable by the air than the gums; it is only capable of abſorbing a little humidity from it, by an hygrometric effect; it exactly follows all the ſtates of the atmoſphere when expoſed to it. Accordingly, in order to preſerve it, care muſt be taken to keep it in a warm and dry place, defended againſt the viciſſitudes of the weather. It diſſolves in water, with which it forms, when well ſaturated with it, a ropy, viſcous liquor, unalterable when pure, and called *ſyrup.* The ſolution, evaporated ſlowly and ſpontaneouſly by the contact of hot and dry air, cryſtallizes; and in this manner it is that ſugar-candy is made. If the ſyrup at the ſame time contains ſome other matter in ſolution,

tion, it paſſes into the vinous fermentation, and forms alcohol, of which I ſhall ſpeak in detail in the order of facts in which I ſhall treat of the ſpontaneous alterations of vegetables. Hot and eſpecially boiling water takes up more ſugar in ſolution than cold water, and forms a liquid more denſe and more tenacious than ſyrup. As this kind of ſolution or ſoftening by means of heat may have ſeveral different degrees of denſity, and become more or leſs ſtrongly ſolid or concrete by cooling, great advantages are derived from this very diverſity of its properties in the art of the confectioner; and theſe different ſtates of ſolution, more or leſs denſe and concreſcible, conſtitute the different degrees of the boiling of ſugar, uſed in froſting of confectionary, or comfits, &c.

22. Though there are certain analogies between the manner in which the powerful acids act upon mucus and upon ſugar, they do not extend as far as chemical authors have carried them, but there exiſt between them very remarkable differences. The concentrated ſulphuric acid reduces it to a coal, converts it in part into water as it does gum; but the nitric acid never converts it into mucous or ſacchlactic acid, as it does gum; the ſugar paſſes at once and immediately (under the ſame circumſtances in which gum forms pulverulent and inſoluble mucous acid) into the ſtate of malic acid, and afterwards quickly into that of oxalic acid, by the continued action of the nitric acid. It is alſo

of all the vegetable ſubſtances that which yields this laſt cryſtallizable acid the moſt eaſily. But it always furniſhes a portion of malic acid at the ſame time, and there always remains a more or leſs abundant portion of the latter in the mother water of the ſaccharine oxalic acid, or that obtained from ſugar, when this mother-water can no longer furniſh cryſtals. This very remarkable difference, this property of not affording inſoluble mucous acid, and of paſſing immediately and at firſt into the ſtate of malic acid, and afterwards very quickly into the ſtate of oxalic acid, has appeared to Citizen Vauquelin and myſelf to depend upon the more oxigenated nature of ſugar than of gum. It is too much ſurcharged with this principle; it is too near to the general ſtate of acid, to be able to form the highly carbonated and very inſoluble mucous acid, to be able to paſs through this firſt degree of inferior acidification. Accordingly, as ſoon as the nitric acid acts upon it, and changes the order of its compoſition, it is not divided into the two firſt acids, the mucous and the malic, but into the two following, the malic and the oxalic. The leſs the acid of nitre has acted, the more the proportion of malic acid exceeds that of the oxalic, though there is always a little of this formed from the commencement of the action of the nitric acid. We here ſee the diviſion of the ſugar into new bodies, a diviſion which invariably characterizes the vegetable ſubſtances.

23. Sugar comports itſelf nearly in the ſame

manner as gum with the alkalis, which cauſe more oil to be obtained from it by diſtillation; and alſo with the nitrate of pot-aſh, which burns its hidrogen and carbon, and inſulates the fixed matters; with the ſuper-oxigenated muriate of pot-aſh, which inflames and detonates ſtrongly with it by percuſſion; with the metallic oxides which burn or decompoſe it; and with the ſolutions of the metals, which alſo precipitate it from its ſolution, and alter it.

24. By the aid of all the means which alter and decompoſe ſugar, we may determine the proportions of its primitive principles, the relative quantities of oxigen, of carbon, and of hidrogen which conſtitute it. Lavoiſier, by uſing the vinous fermentation, which it alone is capable of undergoing, and which conſiſts in a ſpontaneous decompoſition, and in the diviſion into two new compounds, which I have already ſo frequently deſcribed in the vegetable ſubſtances, has found that one hundred parts of ſugar contain ſixty-four parts of hidrogen, twenty-eight parts of carbon, and eight parts of oxigen. Though it appears that this analyſis has not yet been able to receive all that degree of preciſion which it would be poſſible to give it at the preſent day, if we ſhould compare the different reſults afforded by the different means of decompoſition, yet this firſt datum of Lavoiſier, which is not far remote from the truth, ſhows that ſugar is an oxide of carbon and hidrogen, a little more oxigenated than gum, and that it

is in this that its difference conſiſts. It appears, that the converſion of inſipid mucus into ſaccharine matter is effected in vegetables by mere oxigenation, and by a ſlight change of proportion in the principles. It is not improbable that art will hereafter be able to convert the gums into ſaccharine matter; and I have already ſeveral times obſerved, that a ſolution of gum in water, into which oxigenated muriatic acid gas was made to enter, aſſumed a ſaccharine taſte, mixed indeed with a ſtrong bitterneſs. This proſpect which is ſtill very new, muſt lead to many uſeful reſearches and reſults. It is already acknowledged by ſome modern chemiſts, that the mucous and feculent vegetable ſubſtances are frequently converted in the ſtomach, by the proceſs of digeſtion, into ſaccharine matter; and it is in this manner that Meſſrs. Rollo and Cruickſhank believe the diabetes mellitus to be produced.

E. *Species or Varieties of Sugar.*

25. We have already ſeen that the ſaccharine matter is never pure and inſulated in vegetables, as mucus ſo often is; that it is united ſometimes with mucilage, ſometimes with fecula, or extractive, and one or more colouring matters; and when we wiſh to have it pure, we are obliged to employ different means in order to ſeparate it from theſe foreign bodies; there are, however, ſome ſaccharine ſubſtances, which are uſed

impure, and ſuch as nature preſents them. Hence it reſults, that four principal ſpecies of ſaccharine ſubſtances, more or leſs in uſe for the common purpoſes of life, are to be diſtinguiſhed; namely, ſugar, properly ſo called, the ſugar of the maple, honey, and manna. Though ſome ſaccharine fruits are uſed in ſeveral countries, as ſubſtitutes for one or other of thoſe ſubſtances, they are only to be conſidered as very imperfect mixtures.

A. I have already ſpoken of ſugar, properly ſo called, becauſe it is the pureſt ſaccharine product, that which is the moſt abundant, and the moſt employed in Europe. It has ſerved in ſome meaſure as a repreſentative of the whole genus. It is known that it is derived from the pilth or medullary and utricular juice, of a gigantic ſpecies of the gramineous plants; that it requires much labour to bring it to its cryſtalline and pure ſtate; that it is not yet even well known in what its preparation and its purification conſiſt, which have not yet been brought to the point of perfection, which may be expected from the preſent ſtate of chemiſtry. This ſugar is employed in different ſtates of purity from the muſcovado and the raw ſugar, the different kinds of caſſonade, the common or officinal ſugar in large loaves, the white and very cryſtalline ſugar in ſmall loaves, the double-refined hard ſugar, very cloſe and very brilliant in its texture, and the ſugar-candy. The ſyrup, and molaſſes are equally applied to a great number of uſes, eſpecially after they have been purified and bleached by heating and cauſing them to throw up their ſkum; by filtrating them through woollen cloths, of a cloſe texture, and ſlightly boiling them with pulverized charcoal.

B. The ſugar extracted from the maple, which in part ſupplies the conſumption of the inhabitants of North America, eſpecially in Canada, forms a ſecond ſpecies very nearly approaching to the firſt in its good qualities, when it is well prepared; it is equally beautiful, equally white, and equally well cryſtallized with that of America, or that of the ſugar-cane; but the labour by which it is procured, is ſtill too long and troubleſome for its quantity to have been yet raiſed to the level of the conſumption, even in the parts of the world where the tree which affords it is the moſt abundant; it appears to be moſt pure in the ſap which holds it in ſolution; it is much more diluted, much more extended with water, and in proportion as its ſolution is condenſed and concentrated, it becomes mucous and coloured. The art of extracting it from the ſap of the maple, is yet very far from having been brought to the perfection which it is capable of attaining, when the lights and the inſtruments of modern chemiſtry ſhall have been applied to it. Perhaps this ſap might firſt be graduated or concentrated by congelation, and thus the great labour and expenſe of its evaporation diminiſhed.

niſhed. It would firſt of all be neceſſary carefully to analyze the ſap of the maple.

C. Honey is the only ſaccharine ſubſtance that was employed in antiquity. It has been pretended that the ancients knew, by proceſſes of purification analogous to thoſe that are practiſed for ſugar, to extract from it a ſolid and concrete matter, capable of being preſerved; but there is no hiſtorical monument to prove the truth of this aſſertion, though there is nothing that directly oppoſes the ſucceſs of ſuch a labour. It is, however, much more probable, that the ancients, who carefully diſtinguiſhed the different ſpecies of honey, and who uſed the greateſt induſtry in the keeping of bees, employed different ſpecies, according to the uſes for which they were deſtined, and ſelected for ſome of theſe uſes, a concrete and granulated ſpecies, more or leſs ſimilar to our ſugar, properly ſo called. Honey is nothing more than the nectar, or the ſaccharine and aromatic juice which the bees collect from flowers, and which they carry in their neſts or hives, for their own ſubſiſtence in the cold ſeaſon, and for that of their young. It eſpecially accompanies the female organs of generation in plants, and is found at the baſe of the piſtils of flowers; generally, it even impregnates the ſtyle, which contains it throughout the whole of its continuity, as we perceive by ſucking theſe parts of the flowers. It ſeems to ſerve, to fix, and conduct the fecundating effluvia of the pollen. Honey is a combination of ſaccharine matter, and aromatic or odorous mucilage. The mucus ſubſtance which it contains gives it viſcoſity, a kind of glutinous quality, deliqueſcence, and renders it difficult to be purified.

D. Manna is the fourth ſpecies of ſaccharine matter which I diſtinguiſh in this genus. It is a gummous ſaccharine juice, coloured by a nauſeous extractive matter; its taſte alſo is diſagreeable and very different from that of ſugar, properly ſo called. It iſſues ſpontaneouſly in ſmall drops, which form ſolid grains, from the leaves of the pine, the fir, the oak, the juniper-tree, the willow, the fig-tree, the maple, and the olive-tree. It is alſo ſeen in the form and by the name of honey-dew, upon the leaves of the elm, the linden, and the yoke-elm, the upper ſurface of which it covers with a light and poliſhed integument. Lobel and Rondelet have deſcribed, by the name of alcomeli, that which is found upon the olive trees, in the vicinity of Montpellier. Tournefort has likewiſe collected ſome upon the trees in the neighbourhood of Aix and Toulon. But the trees which furniſh the moſt of this juice, and from which that which is employed in medicine is extracted, are the aſh, the larch, and the alhagi.

The aſh, which grows in abundance in all the temperate climates, yields, more eſpecially, a large quantity of manna, in Sicily and Calabria. Though the manna collects upon the ſutures of its leaves, a much larger quantity is obtained by making inciſions into the tree. The ſaccharine juice runs out through the apertures, and attaches itſelf as it dries upon the trunk of the trees, from which it is taken off. When ſtraws or ſmall ſticks are placed in the inciſions, the manna is formed, by incruſting itſelf upon them, a kind of ſtalactites, which are termed *manna in tears*: this is the fineſt and the pureſt kind. The fragments which are collected upon the tree itſelf, and which are irregular, leſs pure than the firſt ſpecies, form the manna in ſorts; as to the pieces which fall on the ground, and which are mixed with much filth, they are termed *fat manna* (*manne graſſe*), becauſe they conſiſt of impure tears, glued to each other by a brown, viſcous, and as it were fatty juice. The aſh ſometimes yields manna in our ſouthern departments. Citizen Chaptal has ſeen ſome which had been collected at Aniane, about two myriameters diſtance from Montpelier.

The larch, which grows in abundance in the vicinity of Briançon, affords, during the ſummer, a kind of manna in ſmall grains, which the inhabitants collect upon the ſutures of the leaves of this tree, and put into pots, which they keep in cool ſituations. This kind of manna becomes very yellow, diffuſes a diſagreeable ſmell, and has a much more nauſeous taſte than the manna of the aſh.

With reſpect to that of the Alhagi, it flows from a ſhrub, a ſpecies of geniſta or broom which grows in Perſia, and reſpecting which Tournefor fort has given intereſting details. It is in the form of ſmall grains, which the heat of the ſun has dried upon the tree. This manna of the Alhagi is ſold in the town of Tauris, by the name of *tereniabin.* It is ſcarcely known or employed in Europe.

Manna boiled in a little water, clarified with the white of egg, and ſufficiently condenſed, affords real cryſtals of ſugar.

26. It is now aſſerted, according to the experiments of Mr. Achard, of Berlin, that ſolid and cryſtallized ſugar may be extracted from the white beet-root, with red veins; that this ſpecies of ſugar may be ſubſtituted in the place of that of the ſugar-cane cultivated in America and Africa, and that it may be afforded at a much lower price. The experiments which are repeating in France upon this ſubject, will ſoon inform us what we have to think of this application of this already ancient diſcovery of Margraff.

F. *Uses.*

57. The ſaccharine ſubſtance is an aliment much ſought after by a great number of animals, and eſpecially by inſects. We ſee moſt of theſe, and eſpecially the inſects with trunks, aſſembling about the ſaccharine juices, attracted even by fragments of ſolid ſugar that have no ſmell, and eagerly ſeizing upon it. It is well known how many inſects inhabit flowers,

and derive their nouriſhment from their nectaries. Man alſo finds in it a part of his ſubſiſtence; numerous facts, and eſpecially what happens in the ſugar colonies, prove that this ſubſtance may ſerve him in the place of food. However, amongſt moſt cultivated nations, it is uſed merely as a condiment, but as ſuch its form is extremely varied, and it is employed for very numerous uſes. It ſerves to preſerve a multitude of ſubſtances, which without it, would be more or leſs alterable, as is proved by the art of the confectioner. It ſoftens the acrimony, improves the taſte, and diſguiſes the inſipidity of many vegetable ſubſtances or foods. Nature herſelf has pointed out its uſe to man, by preſenting it to him in a great number of alimentary ſubſtances formed by the plants, and by uniting it with the inſipid mucilage, the taſteleſs fecula, the pungent acid, the ambroſiacal aroma, &c.

28. Sugar is alſo one of the medicinal ſubſtances moſt in uſe, one of the ſubſtances that are the moſt frequently and the moſt abundantly adminiſtered to the ſick. It is particularly ranked amongſt the emollients, and the ſlight bracers, or even the analeptics, the relaxing, or rather the laxative medicines, and the antiſeptics. It ſerves to ſweeten all medical draughts; and when we calculate the quantity which the ſick generally take of it, we find, that it is ſufficient to ſuſtain, to nouriſh, and to ſupport, ſometimes more even than is neceſſary, the ſtrength re-

quiſite for the cure of their diſorders. If it be ever ſo little combined with foreign ſubſtances, eſpecially thoſe that have a more or leſs diſagreeable or nauſeous taſte, it becomes purgative, as we ſee in the different kinds of honey, of manna, and in a great number of the laxative fruits. Its antiſeptic and preſervative property ſhows itſelf even when we cover the fleſh of animals, fruits, &c. with a more or leſs thick layer of this ſubſtance in powder. Its agglutinating, and as it were, aſtringent quality, renders it very fit for curing wounds, or cuts, for ſtopping ſlight hemorrhages, by cloſing the lips of a recent wound, and even diminiſhing to a certain degree the bad condition and putreſcency of old ulcers, &c.

29. Sugar is alſo employed in the arts for a great number of uſes, for giving brilliancy to varniſhes, to ink, to paintings, to ſome ſlight ſurfaces; for imparting an agreeable taſte to the mouth-glue; for making ſticking-plaſter; it is the baſe, or the recipient, of a great number of pharmaceutical preparations, &c.

ARTICLE VII.

Of the fourth of the immediate Materials of Vegetables, or the Vegetable Acids.

SECTION I.

Of theſe Acids in general, of their nature, their Enumeration, and their Claſſification.

1. THOUGH we may in general conſider, as a ſingle one of the immediate materials of vegetables, that acid, which is ſo abundantly contained in them; though we may be allowed to believe that this ſubſtance, which is ſo well characterized and ſo eaſily known, is, wherever it is met with in plants of their products, one and the ſame matter differently modified, and poſſeſſing ſome varied diſtinctive properties according to ſome ſlight ſhade in its compoſition, which is always the ſame, always identical,—it is nevertheleſs difficult to avoid conſidering as real ſpecies thoſe among the vegetable acids that preſent the greateſt differences from one another, whether in the properties which all men diſtinguiſh in them, or in the uſes more or leſs remote from each other to which they apply them, according to the very diſſimilar qualities which they have obſerved.

2. It will never be poſſible to confound the very agreeable acid juice of the lemon, of apples, or of vinegar, with the aſtringent tartneſs of nut-galls, and the burning acrimony of the acid extracted from Benzoin. It is true that modern chemiſtry has been able to approximate, by its learned ſpeculations, and almoſt to confound by its ingenious experiments, the juice of apples with the acid of ſorrel, the acetous acid, &c.; but it has not yet done the ſame with all the vegetable acids. Though ſeveral of them have already been converted by its powerful means into one another, they have not yet all undergone this ſpecies of metamorphoſis; and though we are permitted to hope, either that all theſe converſions will be effected by future experiments, or that we ſhall find out the true cauſes of the failure of theſe tranſmutations; it is no leſs certain, that in the preſent ſtate of our knowledge it is neceſſary carefully to diſtinguiſh the different acids which the vegetables preſent to us.

3. This part of chemiſtry has made immenſe progreſs from the year 1776 to the preſent day. At the former period ſcarcely two acids different from each other were diſtinguiſhed in vegetables, namely, that which was native in them and which was always believed to be a kind of tartar, and that which was the product of fermentation; and nevertheleſs, the number of the four plants was found to be immenſe in the firſt and moſt ſuperficial aſſays of the

chemiſts; the number of thoſe which were obtained in the changes which vegetables were made to undergo by the analytic means to which they were ſubjected, appeared equally conſiderable. In the preſent ſtate of chemiſtry we reckon at leaſt fifteen ſpecies of vegetable acids: the labours of Bergman and Scheele firſt opened this brilliant career, which many modern chemiſts have followed with a rapid pace.

4. All theſe acids of whatſoever kind, artificial or factitious, are compoſed of analogous principles. We conſtantly find in them, by exact analyſis, carbon, hidrogen and oxigen; they are all reduced by the oxigenating or burning proceſſes into water and carbonic acid. We ought, therefore, to conſider them as acids with binary radicals, *hidro-carbonated* or *carbo-hidrogenated*, united with different proportions of oxigen, which differ from the vegetable oxides properly ſo called, or from the immediate but not acid materials of vegetables, only by their ſuper-abundance of the acidifying principle. In this manner, it will eaſily be conceived how the oxides are converted into acids, whether by the action of fire, or by that of the decompoſable acids with ſimple radicals, or by fermentation. In this manner alſo may be explained the reciprocal converſion of ſeveral of theſe acids into one another. In order to effect any of theſe converſions, it is ſufficient to produce a variation in the proportions of the principles which conſtitute the

materials or theſe acids: almoſt always we extract from them different quantities of hidrogen or of carbon, or both at the ſame time, and we augment the quantity of oxigen ſo as to complete their acidification.

5. When we try the plants which we meet with in our walks, with very ſenſible blue paper, moſt of them exhibit marks of acidity; but moſt of them, when treated with more exactneſs in their juices, are found to contain ſeveral acids at the ſame time; and it is very rare, perhaps even impoſſible, to find a ſingle acid in any one part of plants, eſpecially in the juices of acid fruits. The ſame phenomenon is obſerved when by treating the different vegetable oxides, and eſpecially mucus, the ſaccharine matter, the fecula, &c. by the different oxigenating or acidifying proceſſes, we convert them into acids: We obtain from them at leaſt two ſpecies, frequently three at a time. In this manner I have converted the ligneous ſubſtance into four acids, and I have even found five different ſpecies in crude and four wines of the vicinity of Paris. It therefore appears that art imitat[illegible] the proceſſes of nature in the fabrication of th[illegible] acids; for there are always ſeveral of them tog[illegible]ther, though I muſt here remark, that the aci[illegible] ſimultaneouſly preſented by Nature in a gre[illegible] number of vegetable ſubſtances, are frequentl[illegible] of the claſs of thoſe which art has hitherto bee[illegible] unable to imitate.

6. I[illegible]

6. In order to know the numerous ſpecies of vegetable acids, for I here comprehend thoſe only which have hidrogen and carbon for their binary radical, and not the acids with ſimple radicals, the ſulphuric, the nitric, the carbonic, which are frequently found combined in the vegetable ſubſtances; it is neceſſary to admit a methodical diviſion between them, a claſſification which enables us to compare them, regularly to explain their diſtinctive characters, their analogies and their differences. With this intention I diſtinguiſh them into ſix genera.

In the firſt I comprehend the native vegetable acids, which exiſt pure and uncombined in plants: this genus includes five ſpecies, viz. the gallic, the benzoic, the ſuccinic, the malic, and the citric.

In the ſecond genus I rank the acids partly ſaturated with pot-aſh, which are termed vegetable acidules, and which include two ſpecies, the oxalic acidule and the tartarous acidule.

The third genus comprehends the acids formed by the fire, or the empyreumatic; of which there are three ſpecies, the pyromucous, the pyrotartarous, and the pyroligneous acids.

To the fourth genus I refer the factitious or artificial acids, which art forms by the action of the oxigenated bodies, or of the powerful acids, upon ſome of the immediate materials of vegetables, and which have not yet been met with in nature. This genus comprehends three ſpecies, viz. the mucous, the camphoric, and the ſuberic acids.

In the fifth genus I place the artificial acids analogous to the preceding in their factitious oxigen, or produced by art, but which are ſimilar to thoſe which are alſo found ready formed in nature. This fifth genus contains two or three ſpecies, the malic acid, the tartarous acid, concerning which there is ſome doubt relative to its artificial formation, as I ſhall ſhow hereafter, and the oxalic acid.

Finally, I form a ſixth genus of the vegetable acids produced by fermentation; there are as yet only two ſpecies, the acetous and the acetic acids, belonging to this genus, though it is very probable, as I intend to ſhow, that fermentation is capable of producing a greater number of them, which have not yet been examined with ſufficient accuracy to enable us to diſtinguiſh them as particular ſpecies.

SECTION II.

Of the firſt genus of the Vegetable Acids, or of the native and pure Acids.

1. NOTWITHSTANDING the immenſe quantity of ſpontaneouſly acid plants and vegetables which are found in abundance and in all latitudes, chemiſts, in examining plants, have

ve hitherto found only five ſufficiently diſtinct cies, differing from each other. It is not, vever, to be imagined that the diſcoveries entirely terminated, or that no hopes are be entertained of diſcovering hereafter a ater number of them, when the naturally d vegetables ſhall have been better exaned.

2. Though I indicate this firſt genus as con ning native and pure acids, I do not ſpeak of irely inſulated and purified acids, and this ity is to be underſtood only as relative to the ds of the ſecond genus which are partly ſaated with pot-aſh: in fact, theſe are ſuffintly exempt from pot-aſh and from ſaturan; but they are not completely inſulated l ſeparated from all foreign matter. They found mixed with mucilage, with acid ces, with light fecula, with colouring matter; l it is neceſſary to employ different means order to obtain them in the ſtate of purity per for examining their properties and their racters.

3. Of the five ſpecies of acids comprehended his genus, three, the gallic, the benzoic and ſuccinic may be obtained in a cryſtalline m by ſublimation; a fourth aſſumes a very ular cryſtalline form by the evaporation of ſolution, namely, the citric acid; the fifth not acquire this cryſtallization, but always nains in a magma; this is the malic acid. is, therefore evident, that if we knew only

this

this property, we ſhould be able eaſily to diſti guiſh them from one another; but their exa hiſtory will furniſh many other characters diſtinction between them.

SPECIES I.

Gallic Acid.

A. *Hiſtory, Seat, Extraction, Purification.*

1. THE name of gallic acid is applied to that which is extracted from the nut-gall more abundantly than from any other vegetable ſubſtance, though it is alſo contained in the wood and the bark of the oak, of the aſh, the willow, in Peruvian-bark, the Simarouba, the pomgranate, ſumac, the root of tormentilla and biſtort, the cone of the cypreſs, the ſhell of the walnut, the ſtalk of the Iris of the Marſhes, &c. Chemiſts were acquainted with the property which all theſe ſubſtances poſſeſs of precipitating the ferruginous ſalts in the black ſtate, and they attributed it to what they termed their aſtringent property. Macquer, Lewis, Cartheuſer and Gioanetti inveſtigated by ſome experiments, though without adequate ſucceſs, the mode of the operation of theſe ſubſtances upon the ſolutions of iron. Monnet eſpecially announced that the vegetable aſtringents acted immediately upon metallic iron, and coloured

it black. Gioanetti diſcovered that the precipitate of ink was not attractable by the loadſtone, and that the iron does not exiſt in it in the metallic ſtate, as had till then been generally believed.

2. Though theſe facts ought to have led to the concluſion that the principle in the vegetable aſtringent ſubſtances which precipitated iron in the black form was an acid, the academicians of Dijon were the firſt who adopted this opinion, in 1772. They ſhowed that the products diſtilled from the nut-gall blackened the ſolution of ſulphate of iron; that this excreſcence yielded with cold water an extract amounting to a twelfth of its weight, that its infuſion reddened turnſole and blue paper; that the ſame principle that precipitated iron in the black ſtate was ſoluble in the oils, alcohol and ether; that the other acids alſo diſſolved without altering it; that its ſolution in water precipitated the ſulphur of the alkaline ſulphurets; that it decompoſed the metallic ſolutions, and coloured their oxides by uniting with them; that it diſſolved iron immediately, and reduced ſilver and gold, after having ſeparated them from their ſolvents.

3. Theſe approximated details afforded as yet only a general proof of the acid nature of the principle of the nut-gall whereby iron was precipitated in the black ſtate; but they did not furniſh the means of extracting and obtaining this acid ſeparately, and aſcertaining its

characteriſtic properties. It is to Scheele that we owe the diſcovery of this acid, by the proceſs which he publiſhed in 1780 for extracting it pure and cryſtallized. He poured upon one part of gall-nuts bruiſed or reduced to a coarſe powder, ſix parts of very pure water; he left them to macerate for fifteen days at a temperature between 15 and 20 degrees; he filtrated and placed the liquid in a large veſſel of glaſs or of earth in order to expoſe it to the air and let it ſlowly evaporate. A blackneſs, and a thick, and as it were glutinous, pellicle were formed; very abundant mucous flakes were ſeparated; the ſolution had no longer a very aſtringent, but a more ſenſibly acid taſte. After two or three months expoſure to the air, Scheele obſerved upon the ſides of the veſſel in which the liquor was contained, a brown ſtratum adhering to the veſſel and covered with granulated cryſtals, brilliant, of a yellowiſh grey colour: he alſo found a large quantity of theſe cryſtals under the thick pellicle with which the liquid was covered. He then decanted the latter; he poured upon the depoſit, the pellicle, and the cryſtalline cruſt, alcohol which he heated; this ſolvent took up all the cryſtallized acid without affecting the mucilage: he evaporated the alcoholic ſolution, and thus obtained the pure gallic acid in ſmall cryſtals as it were granulated, brilliant, and of a ſlightly yellowiſh colour. It is by this proceſs that the acid of which I ſpeak was prepared after Scheele, till another manipulation came to be known, which ſeems to deſerve the preference over it.

4. Citizen Deyeux gave, ſome years after Scheele, a very good Memoir on the Analyſis of the Gall-Nut. He particularly diſcovered, that by heating this excreſcence of the oak pounded, ſlowly and cautiouſly, in a pretty broad and high glaſs retort, it ſublimes a conſiderable quantity of cryſtals, lamellated, brilliant, ſilvery, conſiderably large, and which poſſeſs all the properties of the ſame gallic acid. He indicates this proceſs for preparing this acid; but I ſhall obſerve that this means, which is much more expeditious than that of Scheele, ſucceeds only when the operation is conducted with much caution. It is neceſſary to apply the fire moderately, to take great care not to puſh its action ſo far as to diſengage the oil, for this carries away and inſtantaneouſly diſſolves all the cryſtals that have been ſublimed previous to its appearance. With the aid of theſe precautions, though the fire conſtantly deſtroys a portion of the gallic acid, we always obtain a pretty conſiderable quantity of it, which is very pure, very white, very well cryſtallized, and in this ſtate undergoes no alteration. We do not find in it, after having extracted it by this proceſs, either extractive or colouring matter which alter it in the proceſs given by Scheele.

B. *Phyſical Properties.*

5. The gallic acid, eſpecially as extracted by the ſecond proceſs, is ſolid, cryſtallized in octahedrons with ſcalenous-triangles, or in brilliant plates, of an acid, pungent, and auſtere taſte, but much leſs ſtrong and aſtringent than that of the gall-nut from which it proceeds; which has induced modern chemiſts to believe that this acid is not the ſole cauſe of the aſtringency, as was formerly thought; and, in fact, the acid obtained by ſublimation has much leſs of an aſtringent taſte than that which is extracted by mere maceration, according to the proceſs of Scheele. By the latter preparation, inſtead of having the acid in plates as by ſublimation, we obtain the gallic acid in ſmall octahedrons of a yellowiſh-grey colour.

6. It is very light, and ſuſceptible of being raiſed into vapour by a gentle heat; it condenſes and cryſtallizes as it cools. In its ſtate of vapour, it has an aromatic ſmell, pungent, and conſiderably analogous to that of the benzoic acid. It is quickly fuſed by the fire, and forms, almoſt at the moment of its volatilization, a thick liquid maſs, brown, ſwelled; exhaling an odorous ſmoke, ſo that there is always a certain quantity of it decompoſed. It ſtrongly colours the tincture of Turnſole.

C. *Chemical Properties.*

7. The gallic acid, though volatile at a degree of heat not very conſiderable, is at the ſame time eaſily decompoſable, ſince every time that we ſublime it, a part of it is always decompoſed. This decompoſition is accompanied with a formation and diſengagement of water, of an acid liquid, of carbonic acid gas, of carbonated hidrogen gas, and of ſome drops of brown oil: it leaves a coal in conſiderable abundance, difficult to be burned and incinerated.

8. This acid is not ſenſibly alterable by the air; it requires twenty-four parts of cold water, or at twenty degrees, to diſſolve it; it cryſtallizes only by a ſlow and inſenſible evaporation: boiling water diſſolves a third of its weight. It precipitates from its ſolution in proportion as it cools, but without a regular form, and diſpoſed only in ſmall grains which do not become white, but remain with their primitive yellow colour. Alcohol diſſolves a much larger quantity of it. This liquid when cold takes up one fourth of its weight. When boiling it can hold a quantity of it almoſt equal to its own; it is precipitated by cooling. When the ſolution of the gallic acid in water is kept in cloſe veſſels, it becomes altered and decompoſed, depoſits mucous flakes, and the acid is gradually deſtroyed.

9. It is not alterable by the combuſtible bodies; charcoal, over which the boiling ſolution is paſſed, whitens it a little. The concentrated ſulphuric acid decompoſes and carbonates it. The nitric acid changes it into malic and oxalic acids. The oxigenated muriatic acid alſo alters it in a particular manner which has not yet been ſufficiently determined though it would be important to aſcertain it.

10. The gallic acid combined with barites, ſtrontian, lime, and magneſia, forms with theſe baſes ſalts of little ſolubility, of a fawn-colour, which an exceſs of their ſeveral baſes cauſes to diſſolve in water, much more abundantly than they naturally combine with it. Its ſaline compounds with pot-aſh, ſoda, and ammonia, are not yet ſufficiently known, nor have they been ſufficiently examined to be well deſcribed. We know in general that they have little ſolubility, and that their generic characters conſiſt only in the precipitation of the metallic ſolutions into coloured gallates, and eſpecially of thoſe of iron, into a black or dark-blue powder.

11. That property which moſt diſtinguiſhes the gallic acid from all the other vegetable acids, is the great attraction which it exerts upon the metallic oxides; it is ſo ſtrong that this acid ſeparates them from the greater number of the moſt powerful acids: the phenomena which the gallic acid, poured into the metallic ſolutions produces, are extremely various. The more readily the oxides abandon their oxigen, the

he more alterable they are by the gallic acid. Poured into the ſolution of gold, it gives it a greeniſh colour, precipitates from it a brown powder, which is ſpeedily reduced into gold, and covers the ſolution with a pellicle of gold, well reduced, brilliant, and metallic. Silver is ſeparated in a brown precipitate from its nitric ſolution, and a light layer of this reduced metal ſoon covers the ſurface of the liquor. Mercury is precipitated in an orange-yellow, copper in a brown, biſmuth in a lemon-yellow, iron in a black ſtate. The ſolutions of platina, of zinc, of tin, of cobalt, and of mangaueſe, are not precipitated by the gallic acid; and it may be here remarked in general, that theſe are preciſely the metals which retain moſt ſtrongly the oxigen neceſſary for their ſaturation, and which are not variable in their oxidation; whilſt thoſe which are precipitable by this acid, ſtop, in general, at different degrees of oxidation, retain but feebly the laſt portion of oxigen which ſaturates them, and are, in general, ſeparated from their ſolvents only at their maximum of oxidation.

12. This has been particularly aſcertained for the ſolutions of iron. Mr. Prouſt has very well proved that ſuch of theſe ſolutions as only contain iron little oxidated, which are ſcarcely coloured and greeniſh, either yield none, or but very little of a precipitate, little coloured, and violet, or of a deep red; that thoſe, on the contrary, in which the iron is ſurcharged with oxigen,

form immediately a very black precipitate; that it would be advantageous in the preparation of the black pigment, the black-dye, or ink, to employ the red, or ſuper-oxigenated ſulphate of iron; that it is for want of employing the latter that we are obliged to agitate the ſtuffs in the air after they have been taken out of the bath, in order to make them abſorb the oxigen which favours the combination of the iron with the gallic acid; that it is for the ſame reaſon that ink aſſumes a fine black colour by its expoſure to the air; that this oxigenating and blackening effect may be produced at the very moment when the mixtures are made by adding oxigenated muriatic acid to them. Such is the very ſimple theory of the fabrication of dyeing mixtures, and of ink, which depend, as we ſee, upon the highly oxidated ſtate of the iron, and its ſtrong union in this ſtate with the gallic acid.

18. The whole account which I have juſt given of the properties of the gallic acid, proves that it contains the moſt carbon of all the vegetable acids, as is demonſtrated by its colour, the facility with which it is blackened by the action of the fire and of the air, its little ſpontaneous alterability, the large quantity of coal which it leaves after its ſolution, that of the carbonic acid which it affords in its decompoſitions by fire, and by the nitric acid. We might conſider it as a kind of carbonous acid, as Citizen Deyeux had conceived it to be, were

we permitted to exclude the hidrogen from its compoſition. But the preſence of the latter principle, which with the carbon conſtitutes its binary radical, and aſſimilates it to all the vegetable acids, and beſides is demonſtrated to exiſt in it by all the phenomena of its decompoſition, oppoſes the admiſſion of this opinion, which otherwiſe is ingenious, though not ſufficiently exact for the preſent ſtate of chemical knowledge.

D. *Uſes.*

14. The gallic acid is much employed in dyeing, and in the preparation of ink; it forms the baſe of all the black dyes, and all the grounds of this caſt, ſuch as the grey, &c. It is never employed in a pure ſtate, but mixed, as it is in the vegetable ſubſtances which contain it, with the aſtringent matter, and eſpecially with tanin. This is the reaſon why the black colour produced by this acid thus mixed, has a red or purple caſt which frequently appears when the black is changed. We may prepare ink much more coloured, much more pure, and leſs alterable with the purified gallic acid, than with the decoction of gall-nuts. This acid is frequently uſed in chemiſtry in order to aſcertain and determine the preſence, the quantity, and even the ſtate of iron in a great number of ſubſtances in ſolution.

SPECIES II.

Benzoic Acid.

A. *Hiſtory, Seat, Extraction, Purification.*

1. OUR firſt knowledge of the benzoic acid is due to Blaiſe de Vigenere, who wrote at the beginning of the ſeventeenth century. He was the firſt who aſſerted that by diſtilling benzoin a cryſtallized acid ſalt was obtained in odorant and acrid needles, which have ſince been termed in pharmacy *Flowers of Benzoin.* Some chemiſts conceived it to be a modified mineral acid, till the properties that were found in this acid, plainly ſhowed it to be a vegetable acid different from all other acids of this claſs. Geoffroy announced, in 1738, that it might be extracted by water. Lemery gave a very good proceſs for obtaining it by ſublimation. Scheele laſtly ſhowed how to ſeparate it from benzoin by means of lime. Mr. Lichtenſtein has publiſhed obſervations on the proceſs of Scheele and on ſeveral properties of this acid.

2. Benzoin is not the only vegetable ſubſtance which affords the benzoic acid; the acid even bears this name only becauſe benzoin is the vegetable ſubſtance which is moſt commonly employed in order to obtain it, and which yields it in great abundance. It is alſo obtained from

pure ſtorax, from the ordinary ſtyrax, from the balſam of Peru, and the balſam of Tolu, from liquidambar, from vanilla, and even from cinamon, the diſtilled water of which depoſits it in cryſtallized needles by cooling and repoſe: it alſo exiſts in the urine of children, frequently even in that of adults, and conſtantly in the urine of the quadrupeds that live on herbs and hay, eſpecially in that of the camel, the horſe, and the cow. There is reaſon to believe that a great number of vegetables, and even of graſſes, contain it more or leſs abundantly, and that it is from this food that it paſſes into the urine. Citizen Vauquelin and myſelf have found ſtrong reaſons for ſuſpecting it to exiſt in the *anthoxantum odoratum,* a herb which is known to impart an aromatic quality to hay. We have found this acid combined with pot-aſh and lime in dung hill water, as well as in the urine of the quadrupeds that have been mentioned.

3. In order to obtain it by the moſt common or moſt uſeful proceſs, benzoin, coarſely pulverized, is put into an earthen pot; this veſſel is covered with a cone of paſteboard, paſted upon the ſides of the pot: the apparatus is placed upon a furnace charged with very little fire, and even of hot aſhes. At this heat the benzoic acid ſublimes and attaches itſelf to the ſides of the cone, which is taken off and renewed every two hours: this is continued till the ſublimed acid begins to be coloured by the oil which immediately ſucceeds it by the action

of the fire. Bucquet ſubſtituted inſtead of this apparatus of Lemery, two ſimple earthen pans, the margins of which were ground, which he luted upon one another, in order to obviate the loſs of all that quantity of acid which exhales through the paſteboard ſides.

4. In the proceſs of Geoffroy, the pulverized benzoin was digeſted in hot water, which having been filtrated, yielded, by cooling, needled cryſtals; but Scheele has obſerved that by this means only a ſmall quantity was obtained, on account of the incapacity of the water to penetrate the reſinous part of benzoin, eſpecially when fuſed, and which always ſwims upon the liquid. On account of this inconvenience, after ſeveral trials with different alkaline ſubſtances, he adopted the following proceſs: one part of quick-lime is taken, which is firſt diluted with three parts of water: about thirty parts of water are added, which are afterwards mixed gradually, and with a motion capable of properly diſpoſing the ſubſtances together, with four parts of benzoin in powder: the whole is then heated over a gentle fire for the ſpace of half an hour, conſtantly ſtirring the mixture; it is then removed from the fire, and left to ſubſide for ſome hours; the clear ſupernatant liquor is decanted; eight parts of water is poured upon the reſiduum, it is boiled for half an hour, and mixed with the former lixivium. The liquor is reduced by evaporation to two parts; muriatic acid is poured into it drop by drop, till—

a ſlight exceſs has been produced, which forms a pulverulent precipitate of benzoic acid by decompoſing the benzoate of lime diſſolved in the lixivium; the precipitate is well waſhed upon a filtre; and if we wiſh to obtain it in cryſtals, it is diſſolved in five or ſix times its weight of boiling water; it is filtrated through linen, and the ſolution having been ſuffered to cool, depoſits long compreſſed priſms. In this operation, the benzoic acid, ſeparated from the benzoin by the lime, forms calcareous benzoate, which diſſolves in the lixivium, and which the muriatic acid decompoſes on account of its more powerful attraction for the lime.

5. Though Scheele, when he publiſhed this proceſs, neceſſarily announced that it affords as much acid as ſublimation, which had produced him only from 0,08 to 0,10 of the benzoin; notwithſtanding the aſſertion of Spielman, who had made the quantity amount to a quarter of the weight of this balſam; yet Mr. Lichtenſtein has pretended, in new Obſervations, publiſhed in Germany ſince the Memoirs of Scheele, that this operation does not furniſh as much acid as ſublimation; but there is reaſon to believe, with Scheele himſelf, and with Citizen Guyton, that Mr. Lichtenſtein, as well as Spielman, reckon into the weight of the benzoic acid, extracted by fire, the impure portion of this ſalt, ſoiled by a ſmall quantity of oil, which greatly increaſes the quantity; ſo that the proceſs of

Scheele is not leſs deſerving of the preference over all the other methods deſcribed before him.

6. We have confirmed the excellence of this proceſs, and, in ſome meaſure, extended its utility, by propoſing to extract the benzoic acid, for chemical and pharmaceutical uſes, from the waters of dung-hills, of ſtables and ſtalls, by means of the muriatic acid, which decompoſes in it the calcareous benzoate, and ſeparates from it the benzoic acid, as in the proceſs of Scheele. This new proceſs will enable us to reap ſome advantage from a ſubſtance that has hitherto been intirely neglected and uſeleſs, namely, the urine of quadrupeds. Should it be feared that the acid obtained by this method might have a foreign ſmell different from that which it ought to have, we may diſſolve it in boiling water, filtrate its ſolution, and ſuffer it to cool in order to obtain from it the cryſtallized acid. By repeating this operation twice in ſucceſſion upon the acid extracted from the dung-hill water, or from urine, we ſhall almoſt intirely deprive it of its ſmell, which, however, is not fetid, but only a little different from that of the acid as extracted from the benzoin. The urine of the buffalo is that which affords the moſt of this acid.

B. *Phyſical Properties.*

7. The pure benzoic acid is in the form of a light powder, ſenſibly cryſtallized, or in fine needles, the form of which is very difficult to be determined on account of their minuteneſs. It is white and brilliant when ſufficiently pure: that which has a yellow or brown tinge, is ſoiled by a certain quantity of volatile oil. It is not a brittle ſubſtance, as its ſolidity and cryſtallized form ſeems to indicate; on the contrary, it is ductile, and, as it were, elaſtic. When we attempt to pound it, it forms a kind of paſte or pulp.

8. Its taſte is acrid, pungent, acidulous, hot, and very bitter. It reddens the tincture of turnſole, but not the ſyrup of violets. It has not a ſtrong ſmell when cold, though the ſlight aromatic odour which it diffuſes may, however, ſerve to diſtinguiſh and characterize it; but it aſſumes a very powerful one when heated, and eſpecially when it is volatilized. It is very light, and occupies a large volume, eſpecially when in the form of long needles intermingled with each other in every direction.

9. When expoſed to a gentle fire, it becomes liquefied, forms a ſoft, brown, and ſlightly inflated maſs, which cools into a ſolid cruſt, preſenting at its ſurface marks of cryſtallization in divergent rays. By the action of a more violent fire it ſublimes and exhales into the air in a white,

acrid, irritating ſmoke, which ſtimulates the eyes, and produces a diſcharge of tears; it is alſo very ſpeedily volatilized when placed upon an ignited coal.

D. *Chemical Properties.*

10. The benzoic acid inflames when heated ſtrongly in contact with the air, when approached to an inflamed body, when touched, liquefied with a red-hot iron, or when ſubjected to the electric commotion. If heated alone in a cloſe apparatus, the greater part is ſublimed without alteration; but a portion is decompoſed, yields a little acid phlegm, a greater abundance of oil than any other vegetable acid, and eſpecially a much larger quantity of carbonated hidrogen gas than all other bodies of this nature. It leaves merely a trace of coal in the retort. In order the better to decompoſe it, it is neceſſary to treat it in a diſtilling apparatus after having mixed it with ſand: by this means we oppoſe its volatilization, and cauſe it to undergo a ſtronger and more lively action of the fire; we then obtain from it much more phlegm, oil, gas, and coal. The proportion of its principles has not yet been exactly determined.

11. It is not ſenſibly altered by the air; it has been kept twenty years in an open veſſel without loſing any of its weight. No combuſtible body alters it; by diſtilling it with pow-

dered charcoal, it is rectified or refined, and obtained much whiter and better cryſtallized than before. It is but very little ſoluble in water. According to Meſſrs. Wenzel and Lichtenſtein, four hundred parts of cold water are required for diſſolving one part of this acid, whilſt the ſame quantity of boiling water can diſſolve twenty parts of it, nineteen of which ſeparate from it by cooling. Bergman aſſures us, that boiling water can take up a twenty-fourth part of its own weight, whilſt at the medium temperature it can ſcarcely take up one hundredth. Its hot ſolution becomes turbid as it cools, and the precipitate thus formed is ſo abundant that it cannot be filtrated through paper, the pores of which it ſtops up.

12. The powerful acids act upon the benzoic acid in a very different manner from that in which they act upon moſt of the other vegetable acids. The concentrated, ſulphuric acid diſſolves it eaſily and without motion, according to Bergman, who, however, remarks, that part of the ſulphuric acid paſſes to the ſtate of ſulphureous acid. We may afterwards ſeparate the benzoic acid unaltered from this ſolution, by adding water to it.

The nitric acid diſſolves it in the ſame manner, and water likewiſe ſeparates it from this ſolution, without its having undergone any decompoſition. Citizen Guyton has found that by diſtilling nitric acid upon the concrete benzoic acid, nitrous gas was not diſengaged till towards tne termination of the diſtillation, and that the acid was then ſublimed without alteration. Mr. Hermſtaedt however aſſures us, that by employing concentrated nitric acid, the benzoic acid became fluid, more fixed than it was naturally, and that it aſſumes the characters of the oxalic tartarous acid: but this reſult ſtill requires to be confirmed by further experiment. The action of the muriatic and the oxigenated muriatic acid upon this acid is unknown, as are alſo thoſe of all the other acids.

13. The benzoic acid unites pretty eaſily with the earthy and alkaline baſes. Hitherto the properties of the benzoates, as well as the particular attractions that ſubſiſt between their principles, have been deſcribed but very briefly. M. Lichtenſtein aſſerts, that it prefers the fixed alkalis, and even ammonia, to the aluminous, magneſian and calcareous earths. According to the obſervation of Citizen Guyton, it does not appear that he employed the pure and cauſtic alkalis in his experiments. Bergman indicates the attractions of the benzoic acid in a different manner. According to him, lime ſeparates the alkalis from it, and barites ſeparates the lime; beſides it diſengages the acid from the carbonates. Mr. Tromſdorf has communicated, in Crell's Annals, a ſeries of experiments upon the benzoates, by which he has aſcertained ſome properties of the earthy or alkaline benzoates. By ſubjoining to theſe ſome facts which I have

collected relative to ſeveral of theſe ſalts, I have preſented the moſt complete account of them that has hitherto been given in the Encyclopedic Dictionary of Chemiſtry, from which I ſhall here borrow the principal reſults.

14. The Benzoate of barites is ſoluble, cryſtallizes very well, remains unalterable in the air, is decompoſed by fire and the powerful acids.

No experiments have yet been made on the benzoate of ſtrontian.

The calcareous benzoate is conſiderably ſoluble in water, much more ſo in hot than in cold water; it cryſtallizes by cooling; it frequently aſſumes the form of dendrites upon the ſides of the veſſels. The ſulphuric, nitric, and muriatic acids decompoſe it; barites takes from it its acid, with which it precipitates. It is found in conſiderable abundance in the urine of the herbivorous mammalia.

The benzoate of magneſia is ſoluble, cryſtallizable, and a little deliqueſcent, more decompoſable than the preceding ſalts.

The benzoate of alumine is conſiderably ſoluble, cryſtallizable in dendrites, deliqueſcent, of a bitter and acerb taſte; it is decompoſed by the action of fire, and even by moſt of the vegetable acids.

The benzoate of zircon is not yet known.

The benzoate of pot-aſh cryſtallizes by cooling into ſmall cloſe needles; the drops of its ſolution, ſpread upon the ſides of the veſſels, form on them, by cooling and evaporation, dendrites, or herborizations, which indicate its cryſtallizability. All the acids decompoſe it; the ſolution of barites, and of lime, form a precipitate in its ſolution.

The benzoate of ſoda is alſo very cryſtallizable and ſoluble; it is not deliqueſcent like that of pot-aſh, according to Bergman. But it is decompoſable by the ſame proceſſes; it ſometimes exiſts native in the urine of herbivorous quadrupeds.

The benzoate of ammonia has alſo appeared to me to be very ſoluble and very cryſtallizable. Like thoſe of all the benzoates, its ſolution depoſits, when it moiſtens the ſides of the veſſels, and when it dries upon them, dendrites and herborizations. It is volatile and decompoſable by all the acids and all the baſes.

15. Mr. Tromſdorf has found, in his experiments, that the benzoic acid did not act upon the metals, but that it united with their oxides.

The benzoate of arſenic aſſumes, according to him, the form of minute feathers, is ſoluble in hot water, and cryſtallizes by cooling. Hitherto we know no benzoates of tungſten, of molybdena, of chrome, of titanium, of uranium, of nickel, of tellurium.

The benzoate of biſmuth is formed, like all the other metallic benzoates which Mr. Tromſdorf has begun to examine, by diſſolving its oxide in the liquid acid. It affords white cryſtals in fine needles by evaporation; fire diſengages the acid from its ſolution, as the powerful acids alſo do.

The benzoate of cobalt cryſtallizes in laminæ; it is decompoſable by pot-aſh, as are all the metallic benzoates.

The white oxide of manganeſe diſſolves well in the liquid benzoic acid. This ſolution yields ſmall ſcaly cryſtals, unalterable in the air, eaſily ſoluble in water, but not in alcohol: the alkalis and the alkaline carbonates decompoſe it.

The benzoic acid eaſily diſſolves the oxide of antimony: the ſalt which it forms is unalterable by the air, decompoſable by fire and by the acids. The benzoic acid does not precipitate the ſolutions of this oxide in the powerful acids.

The oxide of mercury obtained by the alkalis, unites with the benzoic acid, which, when it is pure, does not precipitate the nitrate of mercury. This benzoate is in the form of a white powder, unalterable by the air, inſoluble in water, ſlightly ſoluble in alchohol, decompoſable by the alkalis and the acids, ſublimable with a gentle heat, decompoſable by a ſtrong fire, and by ſulphur.

Neither tin nor its oxide diſſolve in benzoic acid, nor enter into combination with it, according to Mr. Tromſdorf; but by pouring a ſolution of benzoate of pot-aſh into the nitro-muriatic ſolution of tin, we obtain immediately a prea precipitated benzoate of tin, ſoluble in hot water, decompoſable by fire, and not attacked by alcohol. We may form all the metallic benzoates by the ſame proceſs, and it is even the beſt manner of preparing them.

The benzoate of lead, according to the ſame chemiſt, affords cryſtals of a ſhining white colour, ſoluble in water and in alcohol, which the ſulphuric and muriatic acids decompoſe; which are unalterable by the air, and from which fire diſengages the benzoic acid.

The oxide of iron unites eaſily with the benzoic acid, and diſſolves in it; it forms yellowiſh cryſtals of a ſweet taſte, capable of drying and even diſappearing in the air, ſoluble in alcohol, precipitable in the black ſtate by the gallic acid, and into the blue by the pruſſiates, loſing their acid by the action of fire, decompoſable by the pure alkalis which take away the acid, and by the acids which ſeparate it from its baſe.

The oxide of copper, precipitated from its nitrate by the carbonate of ſoda, combines well with the benzoic acid; it forms with this acid ſmall cryſtals of a deep green colour, ſoluble with difficulty in water, and not at all in alcohol, the acid of which is ſublimed by the action of fire, and ſeparated by the other acids, and which the alkalis decompoſe.

The benzoic acid decompoſes the nitrate of ſilver; it unites well with the oxide precipitated from the nitrate of this metal by the carbonate of ſoda. The benzoate of ſilver thus formed is ſoluble in water, and very little ſo in alcohol. It is blackened by the contact of light, the acid is volatilized from it by the fire, and the oxide then eaſily paſſes into the metallic ſtate.

The oxide of gold alſo unites, according to Mr. Tromſdorf, with the benzoic acid; the ſolution of this benzoate of gold yields irregular cryſtals, ſoluble in water, inſoluble in alcohol, unalterable by the air, decompoſable by fire, and eaſily reducible into brilliant and pure gold during the volatilization of their acid.

The oxide of platina, combined with the benzoic acid, yields ſmall yellowiſh cryſtals, unalterable by the contact of the air, ſoluble in water with difficulty, and abſolutely inſoluble in alcohol, and leaving a yellowiſh reſiduum after the action of the fire.

16. From all the collective facts relative to the chemical properties of the benzoic acid, it follows that this acid differs from the other vegetable acids in the nature and the proportion of the principles of its radical. Its ſmell, its volatility, its combuſtibility, its ſtrong ſolubility in alcohol, its little ſolubility in water, had cauſed it formerly to be conſidered as an oily acid, and induce modern chemiſts to think that it contains in its compoſition a large quantity of hidrogen, and that it is by the ſuperabundance of this combuſtible principle, and by the highly hidrogenated nature of its radical,

dical, that it differs from all the other acidified vegetable compounds. That it is ſo little alterable by the acids, and by the oxigenated bodies in general, is becauſe it is too volatile for it to be practicable to render the action of theſe bodies, which requires to be aided by heat, ſufficiently durable, or ſufficiently ſtrong to effect its decompoſition. It eludes it rather by its volatility than by its peculiar nature.

D. *Uses.*

17. If we except its medical adminiſtration, which has now become much leſs frequent than formerly, the benzoic acid is of no uſe in the arts. It is prepared in pharmacy, and made to enter into ſome medical preſcriptions, in the ſolid form of electuaries, boluſes, pills, with extracts, ſyrups, &c. but it is rarely adminiſtered in the liquid form, on account of its acid and burning taſte.

18. It is extracted and purified in chemiſtry, in order to learn its properties, to ſubject it to experiments more or leſs connected, and to examine its combinations. It is, however, one of the acids that are prepared the leaſt frequently, that are met with in the leaſt abundance in the laboratories of chemiſtry, and which are the moſt rarely employed in experiments.

SPECIES III.

Succinic Acid.

THE ſuccinic acid, ſo named, becauſe it is extracted from amber, a bitumen which manifeſtly has a vegetable origin, belongs really to the vegetable acids: it is a combination of hidrogen, carbon, and oxigen, decompoſable in water and carbonic acid, by the action of the fire and the comburant bodies. I here only indicate it, as I ſhall examine it more in detail in the order of facts relative to the alterations which vegetables are ſuſceptible of experiencing in the earth. I place it in the method which I adopt for the acids, in the ſeries of the gallic and the benzoic, becauſe, like theſe it is capable of ſubliming and of cryſtallizing by ſublimation.

SPECIES IV.

Malic Acid.

A. *Hiſtory, Seat, Extraction.*

1. THE malic acid bears this name becauſe it has been more eſpecially found by Scheele in the

juice of apples. It exiſts alſo in a great number of fruits; it exiſts in ſmall quantity, mixed with much citric acid in the fruits of the *vaccinium oxycoccos*, of the *vitis idæa*, of the *prunus padus*, of the *ſolanum dulcamara*, of the *cynoſbatos*. It is found in abundance, and with very little citric acid, in the barberry, the elder, the plum; nearly equal parts of both acids are extracted from the currant, the blackberry, the cratægus aria, the cherry, the raſpberry, the ſtrawberry. Theſe are the reſults of the fine experiments of the Swediſh chemiſt on the juices of all theſe fruits.

2. Notwithſtanding this multiplicity of vegetable matters that contain the malic acid, it is the moſt abundant, and moſt pure, in the apple, and this is the fruit from which it is the moſt eaſily extracted. The following is the method of proceeding, according to the diſcovery of Scheele, in the extraction and purification of this acid. Sour apples are pounded in a mortar, the juice is preſſed out, it is filtrated through linen, and a ſolution of acetite of lead, or *ſaccharum ſaturni*, is poured into this diſſolved ſalt. The acetous acid unites with the pot-aſh, and remains in ſolution in the liquor, whilſt the acid of apples, combined with the oxide of lead, is precipitated in an inſoluble malate of lead. This precipitate is then well waſhed; and treated with ſulphuric acid diluted with water, ſulphate of lead is formed, which is precipitated, and the ſupernatant li-

quor contains the malic acid ſeparate. Care is taken to add a ſufficient quantity of ſulphuric acid to decompoſe the whole of the malate of lead; which is known to have been done by the acid, pure taſte of the ſupernatant liquor, free from any admixture of ſaccharine flavour. Should there be a ſmall exceſs of ſulphuric acid, it is made to diſappear by adding a ſmall quantity of malate of lead, which this acid decompoſes and converts into ſulphate of lead.

3. When the malic acid is found mixed with citric acid, as is the caſe in many of the juices of fruits, and eſpecially in that of the gooſeberry, the following is the method by which Scheele ſucceeded in obtaining each of theſe acids ſeparate. He firſt inſpiſſated this juice to the conſiſtence of honey; he then poured upon it alcohol, which diſſolved the two acids, and left a large quantity of gummy mucilage; he afterwards evaporated this alcohol; he diluted the liquor which remained after this evaporation with two parts of water; he ſaturated it with chalk or carbonate of lime; he ſeparated by evaporation the calcareous citrate which is much leſs ſoluble, and the calcareous malate which remained in it afterwards, by a freſh quantity of alcohol, which did not diſſolve the ſalt, but a ſaponaceous and ſaccharine matter which was combined with the malate of lime; he decompoſed the malate of lime by the acetite of lead; he afterwards treated the malate of lead that was formed with ſulphuric acid, and

thus be obtained the malic acid pure and inſulated.

B. *Phyſical Properties.*

4. The malic acid thus prepared is a browniſh-red liquid, of a conſiderably pungent and lively acid taſte, without acrimony, but frequently affording a ſaccharine after-taſte, however well it may have been purified. It reddens the blue vegetable colours well.

5. It never aſſumes the cryſtalline and ſolid form; it becomes thick and viſcid like a mucilage or ſyrup; when it is expoſed to dry air, it dries in minute layers, like a brilliant varniſh, and might be employed for ſpreading over poliſhed ſurfaces.

C. *Chemical Properties.*

6. This acid is eaſily decompoſed by fire; it tends to loſe carbon ſpeedily; it becomes of a very deep colour, ſwells conſiderably, exhales a thick and pungent ſmoke in the open air, and leaves a very voluminous coal, ſimilar to thoſe of mucilage and ſugar. When it is diſtilled in a retort, it yields acid water, much carbonic acid gas, ſome carbonated hidrogen gas, and a light ſwelled coal. Its empyreumatic acid appears to be the pyromucous acid.

7. It is decompoſed gradually and ſpontaneouſly in the veſſels in which it is contained, it

ferments ſenſibly, becoming at firſt ſlightly vinous, depoſits mucous filamentous flakes, which at laſt are reduced to coal. It is very evident that this decompoſition is produced by the intimate re-action of the component principles of this acid. Its mechaniſm will be ſtill better underſtood from the hiſtory of ſome of the ſubſequent acids.

8. All the powerful acids alter it and change its nature; the concentrated ſulphuric acid reduces it to coal; the nitric acid converts it into oxalic acid. Scheele had already found that inſipid mucous matter, treated by the nitric acid, paſſes into the ſtate of malic acid, or was converted at the ſame time into this acid and into the oxalic. Thus the malic acid is fabricated artificially, and we muſt recognize in it a double origin, that of nature and that of art, as in ſeveral other vegetable acids of which we ſhall ſoon treat.

9. The malic acid forms with barites a cryſtallizable and ſoluble ſalt; with lime it yields ſmall irregular cryſtals, little ſoluble in boiling water, but very ſoluble in an exceſs of malic acid, as well as in vinegar, like the malate of barites itſelf. The malate of lime thus diſſolved by its acid, forms, by thickening in the air, a ſolid, brilliant ſubſtance analogous to a layer of varniſh. The malate of magneſia is deliqueſcent, that of alumine has little ſolubility. The malates of zircone and of ſtrontian are not known. The malates of pot-aſh, of ſoda, and of

ſome days, a harſh, oily, and diſagreeable taſte.

2. Mr. Georgius publiſhed, in the Memoirs of Stockholm for 1774, a better proceſs of concentration. This conſiſted in keeping the lemon-juice for ſome time in a cellar, in inverted bottles, in order to ſeparate from it a part of the mucilage, and afterwards to expoſe it to a cold of from 4 to 5 degrees below 0; the aqueous part was thus congealed, taking with it a portion of the mucilage; this was ſeparated, and the liquid was continued to be expoſed to the froſt, till the concrete portion had an acid taſte. The juice thus reduced to one eighth of its original volume, is eight times ſtronger than before, and it requires the ſame quantity of pot-aſh to ſaturate it as the original quantity of the juice required. In this ſtate of concentration, it remains unaltered, and may be employed for every domeſtic and economical purpoſe.

3. It is well known to every one who has extracted and examined the juice of the lemon, that this liquid, when expoſed to the air in an open veſſel, at a temperature of above 15 degrees, depoſits a mucous, whitiſh, ſemi-tranſparent matter, of a gelatinous conſiſtence. When the juice is decanted from over this depoſition, and filtrated, it is much leſs alterable than it was previous to the operation. The uniform ſubſtance thus ſeparated is not a ſimple vegetable mucilage: I have found that when dried it is not ſoluble in boiling water;

that, if treated by the nitric acid, it yields azotic gas, is converted into malic and oxalic acids, and that it thus has ſome analogy with the glutinous principle. This explains a proceſs followed and deſcribed by Citizen Dubuiſſon Limonadier, at Paris, for the purification and preſervation of lemon-juice. By evaporating it with a gentle heat, continued for a long time, he found that its mucilage became thickened, and ſeparated in the form of a glutinous cruſt and flakes; the acid liquor then becomes concentrated and may be kept for a long time in well-corked bottles; there afterwards ſeparate from it only a few white and ſolid flakes which ſwim upon the ſurface, without the nature of the acid being changed, or its flavor being altered, or loſing any of its ſtrength.

4. Theſe different means, however, were only in ſome meaſure preparatory; they did not yet afford either a method for obtaining the citric acid really inſulated and pure, or an opportunity for examining its properties. Scheele nearly accompliſhed this work by preſenting a proceſs for obtaining the citric acid conſiderably pure; and to him we are at the ſame time indebted for the firſt deſcription of the real diſtinctive characters of this acid, which till this time had been confounded with the tartarous. Stahl indeed knew, at the commencement of the century, that lemon-juice combined with Crabs claws aſſumed the nature of vinegar; ſeveral chemiſts alſo had deſcribed, after him, ſome

properties of the combinations of this acid; but theſe were only vague and inaccurate notions before the diſcoveries of the Swediſh chemiſt. The following is the method by which he ſucceeded in obtaining the real citric acid, after having tried in vain to purify the lemon-juice with alcohol, which does not ſeparate the mucilage completely enough to inſulate this acid, or to admit its being obtained in cryſtals, as may be done when it is ſufficiently pure.

5. The lemons are preſſed, the juice filtrated or drawn off clear is ſaturated with carbonate of lime. After the effervеſcence which diſengages the carbonic acid, a pulverulent inſoluble ſalt is formed, which precipitates to the bottom of the liquid; the ſupernatant water retains the mucilage, the extract, and the colouring matter of the juice; the precipitated citrate of lime is waſhed with lukewarm water, till this paſſes off colourleſs; it takes up only about as much ſalt as it would take of ſulphate of lime: the ſalt waſhed with a little water is poured into a matraſs; a quantity of concentrated ſulphuric acid requiſite for ſaturating the proportion of chalk that has been employed is added, after having diluted this acid with ten parts of water; it is then boiled for a few minutes, and after cooling, the liquor is filtrated: the ſulphate formed by the decompoſition of the calcareous citrate remains upon the filtre; the liquor that has been filtrated contains

the citric acid pure; it is evaporated to the conſiſtence of a clear ſyrup, and put to cryſtallize in a cool place: in this manner we obtain the citric acid in ſmall needles. According to Scheele, it is neceſſary to add a ſmall exceſs of ſulphuric acid, which remains in the mother-water of the cryſtallized acid. This exceſs produces better effects than an exceſs of lime or of citrate of lime, which would prevent the cryſtallization of the citric acid.

6. I have propoſed long ſince to execute this proceſs in the large way in our American poſſeſſions, where lemons are ſo abundant, and where a large quantity of them is loſt; it would only be requiſite to ſaturate the expreſſed juice with chalk, to waſh the precipitated calcareous citrate well till the hot water paſſes off inſipid and colourleſs, to dry the precipitate well, and to ſend it, preſſed in barrels, to France, where it might be decompoſed by means of diluted ſulphuric acid, in order to obtain from it the citric acid pure. This proceſs which I have indicated more than ten years ago in my courſe [of lectures] will be very economical and very uſeful; it will give a value to immenſe quantities of lemons that have hitherto been loſt, and will furniſh a ſubſtance which is ſo often wanted, which is always ſcarce and dear in the North of Europe, and which is ſo uſeful for chemical and medical purpoſes. Since I have indicated it, I have not had the ſatisfaction of ſeeing it put in practice; but this view will not always

be loſt, and it is to be believed, that when it ſhall have been diffuſed amongſt the American coloniſts, it will preſent them with the means of turning to profit a product which is ſo abundant near their habitations, and which they ſuffer to be loſt in ſuch large quantities.

7. Citizen Dizé, an able practitioner of Pharmacy at Paris, by repeating with care and upon a very large ſcale the proceſs of Scheele for extracting the pure citric acid from the juice of the lemon, in the large pharmaceutical eſtabliſhment at the military School, of which he has the direction, has had an opportunity of making ſome important obſervations on this preparation. He has aſſured himſelf, not only that an exceſs of ſulphuric acid is neceſſary for obtaining this acid pure, but that it ſerves to deſtroy the portion of mucilage which alters it, by determining its decompoſition; he has obſerved that, in order to have the citric acid perfectly pure, it was neceſſary to diſſolve and to cryſtallize it ſeveral times ſucceſſively. He has ſucceeded in obtaining it in the form of very voluminous, and almoſt gigantic cryſtals, perfectly formed, and the figure of which he has been able exactly to determine. He has deſcribed its ſolubility, compared its energy, confirmed the facts announced by Scheele, relative to its action upon the ſolutions of ſome earthy and metallic ſalts, and thus rendered its hiſtory more exact.

8. Laſtly, Citizen Vauquelin has undertaken, at my ſolicitation, a ſeries of experi-

ments upon the ſaline combinations of the citric acid, and has greatly added by his reſearches to the ſmall ſtock of knowledge that before exiſted relative to the properties of this acid; ſo that it was now one of the beſt known of all the acids which the vegetables preſent.

I ought here to repeat that the citric acid is rarely found alone, but mixed with different proportions of malic acid in the juices of the barberry, the cherry, the ſtrawberry, the raſpberry, the fruit of the ſervice-tree, the elder, and a multitude of other fruits; that it is eaſily ſeparated from this malic acid on account of the little ſolubility of the citrate of lime which is precipitated, whilſt the malate of the ſame baſe remains in ſolution in the liquor.

B. *Phyſical Properties.*

9. THE citric acid, when ſufficiently pure, cryſtallizes in rhomboidal priſms, the ſides of which are inclined towards each other at angles of about 60 or 120 degrees, terminated at both ends by ſummits with four faces, which intercept the ſolid angles; the beautiful cryſtals are obtained only by letting large quantities of the ſolution of the well-purified acid evaporate to the conſiſtence of a clear ſyrup. The ſmall quantities upon which Scheele operated did not permit him to have it regular, and it is only ſince the operations in the large way of Citizen

Dizé that the perfect form which I have juſt deſcribed has been known.

10. The citric acid has ſo ſtrong and pungent a taſte in this ſtate of cryſtallization, that when taſted, we experience a ſenſation almoſt like that of a cauſtic; it, however, is not ſuch, and when diluted with a little water, its cool, though pungent taſte is agreeable; it is not characterized, or at leaſt but very ſlightly with the ſmell of the lemon. It ſtrongly reddens the blue vegetable colours; it melts very quickly in its water of cryſtallization under the action of the fire.

C. *Chemical Properties.*

11. When the ſolid citric acid is heated upon ignited coals, it ſoon fuſes and runs; it ſwells and exhales an acrid and ſtimulant vapour, which does not reſemble that of fried ſugar or caramel, as that of the malic acid does; treated in the ſame manner it is at laſt reduced into coal, which is not by far ſo abundant or ſo much inflated. Diſtilled in a retort, it is diſengaged in part without decompoſition; it appears to yield a portion of vinegar; afterwards it gives carbonic acid gas, a little carbonated hidrogen gas, and a light coal remains in the retort. In general, it is one of the acids that moſt reſiſt decompoſition by fire.

12. When expoſed to the air, it ſeems to effloreſce in a dry and warm atmoſphere; but it

abſorbs humidity when the air is charged with it, and at laſt loſes its cryſtalline form. It is very ſoluble in water; Citizen Vauquelin has eſtimated that 100 parts of this acid diſſolve in 75 of water at 15 deg.: this ſolution produces ſome degrees of cold. Though it is much leſs alterable than moſt of the other vegetable ſolutions, it is nevertheleſs at laſt decompoſed when kept for a long time in cloſe veſſels; it precipitates mucous flakes; it is probable that it is converted into acetous acid previous to its deſtruction.

13. The citric acid is not altered by any combuſtible body; charcoal alone amongſt theſe bodies appears to be capable of whitening it. The more powerful acids decompoſe it with much more difficulty than they do the other vegetable acids. However, the concentrated ſulphuric acid manifeſtly converts it into acetous acid. The nitric acid, according to Scheele, does not change it into oxalic acid; but Citizen Vauquelin and myſelf have found in our inquiries, that in the courſe of time, by employing a large quantity of it and heating it for a long time, the citric acid is decompoſed by the nitric acid, and converted into a ſmall portion of oxalic acid, and a much larger of acetous acid.

14. The combinations of the citric acid with the earthy and alkaline baſes have been examined with conſiderable care by Citizen Vauquelin.

A. Twelve parts of citric acid diſſolved in water yielded twenty-four parts of citrate of barites. The firſt portions of the ſolution of barites, poured into that of the citric acid, form a flaky precipitate ſoluble by agitation; the precipitate was not permanent till the period when the whole of the acid was ſaturated: this ſalt, at firſt depoſited in the form of powder, collects itſelf afterwards into ſilky tufts, and a kind of ſilvery buſhes, very brilliant and beautiful. A large quantity of water diſſolves it. This citrate contains equal parts of acid and of baſe.

B. Twenty-four parts of citric acid required eighteen parts of cryſtallized carbonate of lime for their ſaturation. 100 parts of this ſalt contain 37,34 of lime and 62,66 of citric acid. When the citric acid had been ſaturated by the lime, ſmall cryſtals were formed, which precipitated themſelves upon the carbonate of lime, and cover it in ſuch a manner as to oppoſe its ſolution, in order to complete which it is neceſſary to ſtir it from time to time. This is the ſalt which is prepared in order to purify and obtain the citric acid: it is known to be very little ſoluble, and decompoſable by the ſulphuric acid.

C. Thirty-ſix parts of acid diſſolved in the proportion indicated No. 12, a proportion which has been conſtantly employed in the experiments of Citizen Vauquelin, required for their ſaturation 61 parts of cryſtallized carbonate of pot-aſh. Hence it follows that 100 parts of citrate of pot-aſh contain 55,55 of acid, and 45,45 of pot-aſh. This ſalt is very ſoluble and does not cryſtallize without difficulty; it is alſo deliqueſcent and decompoſable by barites and lime.

D. 36 parts of acid ſolution abſorbed 42 parts of dry carbonate of ſoda; whence it follows that the citrate of ſoda contains 60,7 of citric acid, and 39,3 of ſoda. This ſalt is very ſoluble; one part requires only 1⅔ of water to diſſolve it. Its taſte is ſaline and faint; it cryſtallizes in priſms of ſix ſides without pyramids; it ſlightly effloreſces in the air without being reduced into powder. It boils, ſwells, and is reduced to coal by the fire. Barites, by decompoſing it, fomrs a precipitate. Lime-water, though it decompoſes it, does not render its ſolution turbid, notwithſtanding the ſparing ſolubility of the calcareous citrate.

E. 36 parts of acid, diſſolved, ſaturated 48 parts of cryſtallized carbonate of ammonia. 100 parts of this ammoniacal citrate contain 62 parts of acid and 38 of ammonia; it is very ſoluble in water; it does not cryſtallize unleſs when its ſolution has been condenſed: the form of theſe cryſtals is an elongated priſm.

F. 36 parts of acid required forty parts of carbonate of magneſia for their ſaturation. One hundred parts of magneſian citrate contain 33,34 of magneſia, and 66,66 of acid. The condenſed ſolution of this ſalt did not cryſtallize, after ſome days, when, by a ſlight agitation,

tation, it aſſumed the form of a ſingle white and opaque maſs, which remained ſoft, ſeparating itſelf from the ſides of the veſſel, and contracting its dimenſions and elevating itſelf in the middle, in the form of a muſhroom nearly twelve centimetres in height.

G. The citrates of ſtrontian, of glucine, of alumine, and of zircone, have not yet been examined.

15. Hitherto the action of the citric acid upon the metals has been little ſtudied: we have ſeen that Scheele found that this acid did not precipitate the nitric ſolutions of the white metals, as the malic acid does. Citizen Vauquelin has ſtudied ſome of the combinations of the citric acid with thoſe combuſtible bodies. The following is a ſketch of his reſearches on this ſubject:

A. Fifty parts of zinc being put into a ſolution of citric acid, an efferveſcence was occaſioned by the diſengagement of hidrogen gas. At the end of twenty-four hours the action was over, and the liquid had depoſited upon the ſides of the veſſel, and at the ſurface of the plates of zinc, ſmall brilliant cryſtals inſoluble in water. One hundred parts contain nearly equal parts of acid and of oxide of zinc.

B. Iron was attacked in the ſame manner as zinc by the liquid citric acid; the efferveſcence continued four days; the ſolution was of a brown colour; by ſpontaneous evaporation it depoſited ſmall cryſtals of citrate of iron. By evaporation it became black like ink, ductile like hot reſin, pulverulent, and very black when cold. This ſalt is very aſtringent and very ſoluble in water. It contains 30,38 of oxide of iron, and 69,62 of citric acid.

C. The citric acid does not attack ſilver, but it unites with its oxide, with which it forms a ſalt inſoluble in water, of a harſh and very ſtrong metallic taſte, which aſſumes a black colour when expoſed to the rays of the ſun, is decompoſed and yields acetous acid, if concentrated by diſtillation, and after this operation, leaves the metallic ſilver in veget-getation, of a very agreeable appearance at the bottom of the retort, mixed with a little coal. This ſalt is decompoſable by the nitric acid; it contains in an hundred parts thirty-ſix of citric acid and ſixty-four of oxide of ſilver.

D. The citric acid does not unite directly with mercury, but it combines very well with its oxide. Red oxide of mercury placed in contact with a concentrated ſolution of this acid, produces a lively efferveſcence, becomes white, and aſſumes a form of a very ſolid maſs. By adding water to this ſolid compound, it becomes white like milk; by heating the liquid, a very ſenſibly acetous ſmell becomes at laſt perceptible. This ſalt is not perceptibly ſoluble, though it has a mercurial taſte. The nitric acic decompoſes it. Diſtilled with a naked fire it yields acetous acid and carbonic acid, without hidrogen gas: the mercury is reduced,

SECTION III.

Second Genus of the Vegetable Acids, or Acidules.

1. THE term of acidules is applied in the methodical nomenclature to the natural combinations of the acids, with a portion of pot-aſh, which remarkably changes their properties.

There are only two of theſe acids that have hitherto been found in this ſtate of ſemi-ſaturation. The other vegetable acids do not affect this ſtate of acidules, as they have not the property of being able thus to unite in part with pot-aſh, and to remain in a ſtate of ſemi-ſaturation with this ſpecies of alkali; the cauſe of the exiſtence of this property in only two, and its abſence in all the others, is yet entirely unknown; it depends, undoubtedly, upon the intimate nature of theſe bodies, and their order of primitive compoſition.

2. At the ſame time that only two acids have hitherto been found to poſſeſs the character of acidulity, it is to be obſerved, that theſe ſame acids are not found, or are found but very rarely in the pure ſtate, and without being ſemi-ſaturated with pot-aſh; which is owing, on the one hand, to the great tendency which theſe

acids have to unite with pot-aſh, or the very ſtrong attraction for it, which they poſſeſs; and on the other, to the circumſtance that this ſpecies of alkali very frequently exiſts in the vegetables. However, we ſhould not be too haſty in concluding, from their never yet having been found pure in vegetable ſubſtances, that they may not ſtill be found in them in that ſtate. Citizen Deyeux already aſſures us, that he has obſerved the not-acidulous oxalic acid iſſuing from the pores of the fibres of chich-peaſe, *cicer, arietinum*; and this diſcovery is ſufficient to announce, that new reſearches may hereafter increaſe our ſtock of knowledge relative to this ſubject; but it is no leſs true, that in the preſent ſtate of chemiſtry this circumſtance ſeems to be very rare in compariſon with thoſe in which the acidules exiſt.

3. I have already remarked, that only two ſpecies of acidules are hitherto known: the one is termed the oxalic acidule, the other the tartarous acidule; but as each of theſe acidules requires the examination of its pure acid in particular, I ſhall treat under each ſpecies of two varieties, namely, of the native acidule, and of the acid which is extracted from it.

SPECIES I.

VARIETY I.

Native Oxalic Acidule.

A. *Hiſtory, Situation, Extraction.*

1. THE name of oxalic acidule is applied to the natural ſemi-ſaturated combination of the oxalic acid with pot-aſh; it is what was termed, previous to the eſtabliſhment of the nomenclature, *ſalt of ſorrel.* It has long been known that ſeveral ſpecies of this genus of plants, and eſpecially that which is termed wild ſorrel, *rumex acetoſella*, as well as the plant termed alleluia, *oxalis acetoſella*, yield by evaporation a concrete acid ſalt. Duclos is one of the firſt who has mentioned it in the Memoirs of the Academy, for 1688; Junker has likewiſe ſpoken of it; Boerhaave has carefully deſcribed, in his Elements of Chemiſtry, the proceſs for obtaining this ſalt, which he has compared with tartar. Margraff firſt diſcovered the preſence of pot-aſh in this acid ſalt, as well as tartar. Since this illuſtrious author, the labours of chemiſts upon this ſalt have been ſo far multiplied, as to render its hiſtory ſtill much more exact than it was at the period when the

chemiſt of Berlin made his reſearches. Amongſt this claſs M. M. Savary, Wenzel, Wiegleb, Bergmann and Scheele are particularly to be mentioned.

2. The oxalic acid, or ſalt of ſorrel is obtained by expreſſing the juice of the plants which contain it, the ſorrel and the alleluia *oxalis* in full vegetation, evaporating it, and letting this inſpiſſated juice cool ſlowly to the conſiſtence of a thin ſyrup. By this firſt operation, it is depoſited in ſmall cryſtals, or cryſtallized plates of a dirty yellow colour. It is re-diſſolved ſeveral times in ſucceſſion, and each time the ſolution is made to cryſtallize, till the acidule is white and pure. According to the number of operations to which it is ſubjected it has different qualities in commerce. Some chemiſts aſſert, that argil is employed in order to purify this acidule; but the fact is neither confirmed nor probable. One hundred parts of oxalis, in full vegetation, afford, according to Mr. Savary, fifty parts of expreſſed juice, which afford only a little more than one two-hundredth part of acidule in conſiderable purity. In commerce we diſtinguiſh the ſalt of ſorrel of Switzerland, which is the whiteſt and the pureſt, and that of the foreſts of Thuringia which is impure and yellowiſh. That of Switzerland is prepared from the *rumex acetoſella*, or the wood-ſorrel; that of Thuringia is extracted from the *oxalis oxitriphillum*, or *alleluia*.

3. Baunach has deſcribed the proceſs which is practiſed in Swiſſerland, and, eſpecially in the Black Foreſt, for extracting the juice of ſorrel from the *rumex acetoſa* of Linnæus. This plant is cultivated in abundance in this country; it is cut in June; it is put in a mortar containing about 300 kilogrammes of juice, and it is pounded with a wooden peſtle moved by water. The juice and the dregs are put into large tubs where it is ſuffered to reſt, water being firſt added to it, for ſeveral days; the whole is ſubjected to a preſs ſimilar to that uſed for grapes; the marc or dregs is pounded a ſecond time, after a freſh quantity of water has been added to it, and it is expreſſed a ſecond time. All the juice that has been collected is ſlightly heated and poured into ſeveral vats; water is added, in which fine argil has been mixed, in the quantity of nearly one hundredth part of the juice; the liquor is decanted, and that which contains the marc is filtrated through fine woollen cloth. The juice thus clarified is put into large boilers of tinned copper; it is gently boiled and evaporated till its ſurface is covered with a pellicle; it is then poured into earthen diſhes, which are placed in cool ſituations, where they are ſuffered to remain quiet for a month; the liquor is then decanted, and an irregular greyiſh ſalt is found upon the ſides of the veſſels; the liquor is evaporated a ſecond and a third time, and a ſmall quantity of argil is added to it. The laſt mother water contains

muriate and ſulphate of pot-aſh; it is ſtill ſour, and appears to contain another acid. The ſalt is purified by diſſolving it in a ſufficient quantity of water, and cauſing it to cryſtallize. According to the experiments of the author, the juice of ſorrel yields a little leſs than $\frac{1}{100}$ of its weight of purified acidule.

4 The oxalic acid may be formed in the direct way, as it was firſt formed by Scheele, by combining with the artificial oxalic acid already indicated, and which ſhall ſoon be deſcribed, about one-fourth part of its weight of pot-aſh: this is an experiment which is performed with ſucceſs daily in the laboratories of chemiſts; by throwing a little liquid pot-aſh into a concentrated ſolution of oxalic acid, ſmall cryſtals of acidule are ſoon precipitated.

B. *Phyſical Properties.*

5. THE pure oxalic acidule of commerce is in ſmall white needled or lamellated cryſtals. Capeller and Ledermuller have repreſented them by the microſcope; nevertheleſs their form has not yet been very exactly determined. Romé de Liſle has defined them as conſiſting of very elongated parallelopipedons. When we break them, we perceive in them groups of leaves or plates applied one above the other: it is always of an opaque, and not very brilliant white colour, except in the ſmall fragments which are ſeparated by the fracture.

6. Its taſte is four, pungent, and a little acerb; it ſtrongly ſets the teeth on edge; it is not mixed with any foreign taſte, being neither bitter nor acrid; it is not diſagreeable, but on the contrary pleaſant and cooling; it ſtrongly reddens blue vegetable colours; it is very brittle; is eaſily reduced into a very dry powder; it crackles and decrepitates in the fire, but cannot be fuſed without a more or leſs conſiderable alteration in its principles.

C. *Chemical Properties.*

7. If we expoſe oxalic acidule upon an ignited coal, it ſwells but little; it exhales, almoſt without becoming coloured, a very pungent and very four ſmell; it leaves ſcarcely any coal, and appears to ſublime. Before the blowpipe it quickly diſappears, and leaves only a little alkaline aſhes, after having been treated in this manner. Four hundred and eighty parts of this acidule were diſtilled in a glaſs retort, by a well-regulated fire, by Mr. Wiegleb; they yielded one hundred and fifty parts of a very acid water, without ſmell and without colour. There remained 160 parts of a grey reſiduum, from which were extracted 156 of pot-aſh; about four parts of a concrete acid were ſublimed into the neck of the retort; not a drop of oil paſſed over. Mr. Weigleb has made no mention of elaſtic fluid; but it is eaſy to

conclude from the 166 parts of loſs, which he had in his operation, that carbonic acid gas and a little water were diſengaged, which he did not collect. The acid obtained in this diſtillation appears to be pure oxalic acid; whence it follows, that the acidule does not undergo any ſtrong alteration by this treatment, and that it is only in part ſeparated from the pot-aſh.

8. The oxalic acid does not ſuffer any alteration by the air; when expoſed to it, it remains dry and cryſtallized, without either its form, conſiſtence, or colour being changed. It is very ſoluble in water: according to M. Wiegleb, one part is diſſolved in ſix parts of boiling water; but he adds, that it is almoſt intirely precipitated by cooling, notwithſtanding the addition of ſix more parts of cold water. Mr. Wenzel carries its ſolubility ſtill farther, ſince, according to him, boiling water takes up more than two-thirds of its weight: cold water, however, takes up or retains about a thirtieth part of it. Boiling water, which diſſolves it ſo much more abundantly, ſuffers it to ſeparate in cryſtals, by very ſlow refrigeration. It is purified and obtained well cryſtallized by this proceſs.

9. The cold and ſaturated ſolution of oxalic acid has a ſour, pungent taſte that ſets the teeth on edge; it reddens the blue vegetable colours. When kept for a long time it cryſtallizes regularly without being decompoſed or its nature

changed; this preſervation, or exemption from ſpontaneous decompoſition, is one of the diſtinctive characters of this acidule, by which it is moſt diſtinguiſhed from the ſecond ſpecies, or the tartarous acidule, which, like many vegetable acids, is ſuſceptible of alteration, and entirely loſes its acidity. Citizen Berthollet has well deſcribed the decompoſition of the latter, and the non-decompoſition of the oxalic acidule, in a Memoir, the principal reſults of which I ſhall preſent to the reader.

10. The acids decompoſe, though with difficulty, the oxalic acidule, which is nothing but the acidulous oxalate of pot-aſh; according to Mr. Wiegleb, by heating this acidule with ſulphuric acid, the diſengagement of its acid is promoted; the nitric acid alſo ſeparates it, according to the experiments of Margraff, but in a very different manner than it does the tartarous acid from its acidule; it was by this proceſs that he proved the preſence of pot-aſh in both of theſe acidules. The muriatic acid effects the ſame decompoſition, though with more difficulty, and leaves muriatic acid in the liquor. Theſe decompoſitions, however, are effected only by the aid of heat; in the cold none of theſe acids ſeparates the acid from its acidule; which is owing to its attraction for the pot-aſh.

11. Several earthy and alkaline baſes unite with the oxalic acidule without decompoſing it,

and cauſe it to paſs into the ſtate of a triſule or triple ſalt. Such particularly are barites, magneſia, ſoda, and ammonia. The triple oxalates have not yet been examined with the attention requiſite for determining their characteriſtic properties. Pot-aſh forms with it ſaturated oxalate of pot-aſh, which ſhall be deſcribed hereafter. Lime decompoſes it by ſeizing the whole of its acid, both that which is free, and, as it were, inſulated; and that which is more engaged in the portion of pot-aſh which it contains. Chalk, or carbonate of lime, effects the ſame decompoſition: it has been aſcertained that 100 parts decompoſe 137 parts of oxalic acidule, that 175 parts of precipitated oxalate of lime, are obtained, and that the ſupernatant liquor yields thirty-two parts of carbonate of pot-aſh. This decompoſition proves that lime has a ſtronger attraction for the oxalic acid, and ſeparates it from pot-aſh.

12. The oxalic acidule decompoſes all the calcareous ſalts, the ſulphate, the nitrate, the muriate, the phoſphate, becauſe its acid has a ſtronger attraction for lime than thoſe acids have; accordingly, it may be generally applied to aſcertain the exiſtence of thoſe kind of ſalts, and even their proportion or their quantity. I ſhall ſpeak again more fully concerning this important fact, in treating of the pure oxalic acid.

13. The oxalic acidule attacks iron, lead, tin, zinc, and antimony, but does not affect the other metals; it diſſolves almoſt all the

metallic oxides with which it forms triple ſalts, almoſt all cryſtallizable, and not deliqueſcent, by combining with them intire and without loſing its pot-aſh. The properties of theſe very ſingular ſalts have not yet been ſufficiently examined. As the ſame acidule in ſolution precipitates the nitric ſolutions of mercury and ſilver into inſoluble metallic oxalates, Bayen, by examining the ſupernatant liquors of thoſe precipitations, and finding in them nitrate of pot-aſh, has confirmed, by this eaſy and ſimple operation, the preſence of that alkali in the ſalt of ſorrel.

14. I have here indicated only the chemical properties that belong to the acidulous oxalate of pot-aſh, or the oxalic acidule, ſuch as it is extracted from ſorrel and ſome other plants, under the name of ſalt of ſorrel: from theſe I have carefully ſeparated all thoſe that depend ſolely upon the pure oxalic acid, as I ſhall ſhow in the hiſtory of the latter in particular. According to the analyſes that I have quoted, the oxalic acidule contains more than one-third of pot-aſh; the reſt of its weight is formed of oxalic acid and water.

BIBLIOTHECA BODLEIANA

D. *Uſes.*

15. The ſalt of ſorrel is eſpecially employed for taking out ſpots of ink from white piece-goods, by reaſon of the very ſolvent action which it exerts upon the gallate of iron. It is

alſo uſed in the treatment of diſeaſes in the form of a cooling drink, by triturating it with ſugar, and adding to it a few drops of volatile oil of lemons. The experiments of Citizen Berthollet have ſhown him that the oxalic acidule preſerves fleſh better from corruption than the tartarous acidule; ſo that it has appeared to him that the ſalt of ſorrel might be employed as an antiſeptic with much better ſucceſs than cream of tartar. In chemiſtry, the oxalic acidule is treated, in order to aſcertain its character or properties, and ſometimes to extract the oxalic acid from it, as I ſhall proeeed, to ſhow.

Species I.

Variety II.

Oxalic Acid.

A. *Hiſtory, Situation, Extraction.*

1. ONE of the moſt beautiful and moſt remarkable parts of the hiſtory of vegetable chemiſtry is that which relates to the diſcovery of the oxalic acid. This acid had long remained, as it were, concealed in the ſalt of ſorrel, which had always been confounded, before Bergman and Scheele, with tartar and its acid. When the former of theſe chemiſts had diſcovered, in the year 1776, the converſion of ſugar into

a very ſtrong acid by means of nitric acid, Scheele diſcovered ſome years after, in 1784, that this artificial acid exiſted ready formed in the ſalt of ſorrel, which contained it intire; that Bergman's acid of ſugar might be converted into ſalt of ſorrel, by combining a little pot-aſh with it, and that we may extract from the native ſalt of ſorrel an acid perfectly ſimilar to that which Bergman had prepared from ſugar. This is the reaſon why, on account of this identity, ſince confirmed by all chemiſts, this acid has been termed the oxalic in the methodical nomenclature.

2. The following is the proceſs by which Scheele ſucceeded in extracting from ſalt of ſorrel the pure acid which is contained in it, and ſeparating it from the pot-aſh. The oxalic acidule of commerce is ſaturated with ammonia, by which means a triple ſalt is formed, an oxalate of pot-aſh and ammonia, very ſoluble in water; into the ſolution is poured nitrate of barites alſo diſſolved; a precipitate of oxalate of barites, inſoluble in cold water, is formed, and the ſupernatant liquor retains nitrate of pot-aſh and nitrate of ammonia in ſolution. We are obliged to proceed in this manner in order to ſaturate the free portion of the oxalic acidule with ammonia, which would not otherwiſe decompoſe the nitrate of barites, becauſe it precipitates it only by double attraction. The precipitated oxalate of barites is then well waſhed, and decompoſed by ſulphuric acid which

has much more attraction for barites than the oxalic acid has; the ſulphate of barites which is formed, remains inſoluble at the bottom of the liquor: this is decanted; it is tried by a boiling ſolution of oxalate of barites, in order to ſeparate from it any portion of ſulphuric acid that may ſtill exiſt in it, and when it no longer forms any precipitate by the addition of this ſolution, the liquid, which then contains the pure oxalic acid, is ſeparated or filtrated: by evaporating this liquid to a proper conſiſtence, it furniſhes, on cooling, priſmatic or needled cryſtals of this acid. We may alſo obtain it by ſaturating the oxalic acidule with pot-aſh or ſoda; by pouring the ſolutions of theſe triſules into a ſolution of nitrate of barites, and afterwards decompoſing the oxalate of barites which is precipitated, by the ſulphuric acid.

3. It is ſufficiently known from what I have already ſhown in ſeveral of the preceding articles, that we may form oxalic acid in a direct way with gums or ſugar, treated with the nitric acid beyond the formation of the mucous and malic acids for the firſt, and only of the malic acid for the ſecond of theſe bodies. We ſhall ſoon ſee that a multitude of other vegetable matters, and even of animal ſubſtances, are capable of affording, more or leſs abundantly, the ſame acid in a very pure ſtate, by the action of the nitric acid. It muſt here be added, that this artificial fabrication is frequently more economical and

more eaſily practiſed than the extraction of this acid from the ſalt of ſorrel, becauſe the latter is always very dear in commerce, and in the artificial formation it is only the acid of nitre which is expenſive.

4. Citizen Deyeux has found in the fibres of chich-peaſe, a conſiderable quantity of oxalic acid. After having cut off theſe fibres with ſciſſars at different lengths, thoſe which had remained almoſt intire, ſoon ſhowed a ſmall drop of liquor at their extremity; thoſe that had been ſhortened by one half, took a longer time before they exhibited this effect; and laſtly, the filaments that had been cut off near their origin, did not preſent any exſudation till after a lapſe of 24 hours. When examined with a ſtrong magnifying glaſs, the divided fibres preſented an orifice, the interior part of which was moiſt, conſequently poſſeſſing vegetation. Theſe fibres were then aſcertained to be ſecretory organs, in which was formed a liquid which, by its ſuperabundance, produced a ſmall drop at their extremity. In fact, had they been merely excretory canals, the liquor would have appeared ſooner at the extremity of the divided veſſels. Beſides, Citizen Deyeux found it impoſſible to diſcover the preſence of the ſame liquid in the parts ſituated the neareſt to the place from whence the hairs took their riſe. The author, after having well examined the phenomenon of the production of this humour, has occupied himſelf with inveſtigating its nature. He firſt obſerves, that

ſeveral chemiſts, and particularly Mr. Prouſt, had announced that it was acid, and that it burned the ſhoes of perſons who walked over a field of chich-peaſe. Citizen Deyeux, having agitated intire plants, the fibres of which were provided with ſmall drops of humour in diſtilled water, found, on examining this water, that it was charged with pure oxalic acid, and not in the acidulated ſtate. This is the firſt time that this acid has been found pure and inſulated in vegetables. There is reaſon to believe that by multiplying the ſame obſervation and the ſame chemical examination upon plants from which acid humors ſpontaneouſly flow, and which are much more numerous than is generally imagined, this acid will be found in greater abundance than has been ſuſpected. It is evident how important it would be to confirm the diſcovery of Citizen Deyeux by new reſearches.

B. *Phyſical Properties.*

5. THE oxalic acid cryſtallizes in tetrahedral priſms, the ſides of which are alternately broad and narrow, and which are terminated at each extremity by a dihedral ſummit. When the cryſtallization is very rapid, we obtain only ſmall needles without any determinate form. Sometimes it preſents itſelf under that of ſquare or ſlightly rhomboidal plates.

6. It has an acid and very pungent taſte; we ſhould be inclined to think, on taſting it, that it acted as a powerful and cauſtic acid; nevertheleſs it produces no ſuch effect upon our organs. It is very agreeable when diluted with water; the teeth are ſtrongly ſet on edge by its contact, and it ſoftens and even diſſolves them, like all the oſſeous ſubſtances, by a contact of ſome continuance. Accordingly, ſome modern phyſicians, amongſt thoſe who have begun to apply the lights of chemiſtry to medicine, and, in particular, Citizen Bonhomme, of Avignon, have thought that the ſoftening of the bones in the diſeaſes of children, characterized by the ſoftneſs and crookedneſs of the bones, was owing to oxalic acid formed ſpontaneouſly in their ſtomachs.

7. The acidity of this acid is ſo powerful, that three decigrammes are ſufficient to communicate a very ſenſible acidity to a kilogramme of water; it alſo manifeſtly reddens all the blue vegetable colours: one part of concrete oxalic acid gives to 3600 parts of water the property of reddening paper coloured with the tincture of turnſole.

C. *Chemical Properties.*

8. The oxalic acid, expoſed to the fire, is in part volatilized in the liquid form, and even in the ſolid and cryſtalline form; only a portion

of it is decompoſed at the higheſt temperature, and this portion paſſes into carbonic acid and water; only a very ſmall quantity of coal remains in the retort. The reſiduum is greyiſh, and contains carbonate of pot-aſh with a little charcoal. The following are exactly the phenomena which the cryſtallized oxalic acid preſents when it is heated by degrees. Expoſed to a gentle fire it dries, becomes covered with a white cruſt, and is ſoon reduced into powder; it loſes three-tenths of its weight. Placed upon an ignited coal, it is exhaled in acrid irritating fumes, and leaves only a white alkaline reſiduum, without coaly matter; diſtilled in a crucible, with a ſtrong, though moderate fire, it is fuſed, becomes brown, boils, and yields an acidulous phlegm, is in part ſublimed without alteration, and at laſt affords a little carbonic and carbonated hidrogen gas. By heating it very ſtrongly, we obtain more of the gaſeous product, and of acidulous water, with leſs of concrete acid: the grey maſs which remains at the bottom of the retort is a mixture of carbonate of pot-aſh and coal; it is very remarkable that this acid affords no oil in its decompoſition by fire.

9. The oxalic acid when expoſed to moiſt air, appears to be deliqueſcent; nevertheleſs it becomes pulverulent in hot and dry air; it eaſily diſſolves in cold water, which takes up the half of its weight. When cryſtals of oxalic acid are thrown into cold water, they emit a ſlight ſound,

which announces the ſeparation of their molecules from each other. The ſpecific gravity of this cold ſolution is greater than that of diſtilled water by more than one half. By evaporating this liquor none of the acid is raiſed, even by ebullition. Boiling water diſſolves a quantity of it equal to its own weight, half of which is ſeparated from it by cooling: by performing this operation with caution this acid may be obtained well cryſtallized.

10. The acids with ſimple radicals, act upon the oxalic acid with greater difficulty than upon the other preceding vegetable acids. The concentrated ſulphuric acid turns it brown, and converts it into coal with the aid of heat. The nitric acid decompoſes it by ebullition: it has been ſaid to convert it into vinegar; but this is not probable, for this acid, on the contrary, very eaſily reduces it into water and carbonic acid. This laſt reſult is conſtantly obtained by employing a ſufficient quantity of nitric acid, and heating the mixture for a ſufficient length of time. Citizen Vauquelin and I have found in our inveſtigations, that 100 parts of oxalic acid contain 77 parts of oxigen, 13 of carbon, and 10 of hidrogen; ſo that it is one of the moſt oxigenated acids in exiſtence; and this is the reaſon why it can only be decompoſed totally.

11. The oxalic acid forms with barites a ſalt of little ſolubility, which yields irregular cryſtals, when it is diſſolved in water with

an exceſs of oxalic acid. When we wiſh to diſſolve theſe cryſtals in boiling water, this fluid takes from them the exceſs of acid which they contain, and renders them opaque, pulverulent and inſoluble. The properties of the oxalate of ſtrontian are not yet known. Citizen Vauquelin has obtained it by pouring oxalate of pot-aſh into muriate of ſtrontian. It appears to be inſoluble and compoſed of 0,59 and a half of earth and 0,40 and a half of acid.

12. Saturated with lime, the oxalic acid forms a ſalt inſoluble in water, pulverulent, which is not decompoſable by fire, becauſe the attraction of this acid for lime is ſo ſtrong, that it takes it away from all the other acids. This oxalate of lime turns the ſyrup of violets green.

13. The oxalic acid eaſily diſſolves alumine. This ſolution when evaporated yields a yellowiſh, tranſparent, ſweet maſs, a little aſtringent; deliqueſcent, and reddening the tincture of turnſole. This ſalt ſwells in the fire, loſes its acid, and leaves the alumine a little coloured. The powerful acids decompoſe it.

14. The combinations of the oxalic acid with zircon and glucine have not yet been examined.

15. The oxalic acid may be united with pot-aſh in two ways, either in ſmall quantity, or in ſufficient abundance to ſaturate it entirely. In the firſt caſe the ſalt of ſorrel, the oxalic acidule, or the acidulous oxalate of pot-aſh, is

regene-

regenerated. It is in this fact that the brilliant diſcovery of Scheele conſiſts. On the one hand, he has proved that we can extract from the ſalt of ſorrel, by the proceſs which I have deſcribed, a pure, cryſtallizable acid, in every reſpect ſimilar to that which is fabricated in the direct way with gum or ſugar and nitric acid. On the other hand, he has confirmed his diſcovery by ſhowing that the acid artificially formed, when united with a little pot-aſh, again produces real ſalt of ſorrel; and in fact, if we only pour a little ſolution of pot-aſh into a ſolution of pure oxalic acid, we ſee a very ſpeedy depoſition of ſmall cryſtals, little ſoluble, namely, of oxalic acidule or ſalt of ſorrel. But in the ſecond caſe; that is to ſay, when we ſaturate the oxalic acid with pot-aſh, we have a ſalt very ſoluble, difficult to be cryſtallized, aſſuming the gelatinous form, which cryſtallizes in hexahedral priſms with dihedral ſummits when an exceſs of pot-aſh is added to the liquor. This oxalate of pot-aſh is decompoſable by fire, and by the mineral acids, which ſpeedily precipitate its ſolution into acidule; it is capable of forming again the ſalt of ſorrel or acidule by an exceſs of oxalic acid. It is alſo decompoſable by barites and by lime, which precipitate from its ſolution, inſoluble oxalates of theſe two baſes.

16. The oxalic acid is alſo capable of forming a ſpecies of acidule when combined with a ſmall quantity of ſoda; but when ſaturated

with it, it conſtitutes an oxalate of ſoda very difficult to be obtained cryſtallized, more ſoluble, however, in hot than in cold water, turning the ſyrup of violets green, and which comports itſelf in many reſpects like the oxalate of pot-aſh, with the acids, with ſimple radicals, with its own acid, with lime and with barites. Pot-aſh decompoſes this oxalate of ſoda.

17. Combined with ammonia in ſmall quantity, the oxalic acid equally forms a ſpecies of acidulous oxalate, little ſoluble, and cryſtallizable of which we may, like the two preceding acidules of pot-aſh and of ſoda, ſaturate the exceeding portion of acid with other baſes, and conſequently form a kind of triple ſalts. It was by the ſame order of complicated attractions, that Scheele by ſaturating the ſalt of ſorrel, or the native oxalate of pot-aſh, with ammonia, formed a triple ſalt, which he afterwards decompoſed by the nitrate of barites, in order to obtain, the pure oxalic acid. But if we entirely ſaturate the oxalic acid with ammonia, a neutral ammoniacal oxalate is obtained, which yields by evaporation beautiful cryſtals in tetrahedral priſms terminated by dihedral ſummits, one of the ſides of which, being much broader than the other, intercepts three ſides of the priſm. This ſalt is decompoſable by fire, which diſengages the carbonate of ammonia, and leaves only ſome ſlight traces of coal; and alſo by barites, lime and ſtrontian, which ſeparate the ammonia in the ſtate of gas, and precipitate its ſolution into

inſoluble earthy oxalates; and by magneſia, which unites with a part into a triple ſalt; and by the two fixed alkalis which form ſoluble oxalates. The oxalic acid precipitates it into cryſtals of ammoniacal acidulous oxalate; the powerful acids with ſimpler unknown radicals ſeize the ammonia; the oxalates of pot-aſh and ſoda unite with it into triple ſalts. It precipitates all the calcareous ſalts, and it is one of the beſt re-agents that can be employed for aſcertaining in any liquids the nature and the proportion of theſe ſalts.

18. We muſt add to theſe details relative to the earthy and alkaline oxalates, that all ſuch of theſe ſalts as have conſiderable ſolubility in water, the latter more eſpecially, which appear to be very decompoſable, do not undergo any ſpontaneous alteration in their ſolution; that they may be uſed with advantage, under this relation, not only for determining the preſence and the quantity of theſe ſalts, but alſo for decompoſing the acidulous phoſphate of lime; and that in order to obtain from this all the quantity of phoſphate which it contains, the ammoniacal oxalate muſt eſpecially be employed, as its oxalic acid, by ſeparating all the lime, with which it is precipitated into an inſoluble calcareous oxalite, leaves in the ſupernatant liquor ammoniacal phoſphate, which as is well known is very decompoſable by charcoal.

19. According to Bergman, the attractions of the oxalic acid for the earthy and alkaline baſes

are to be diſpoſed in the following order: lime, barites, magneſia, pot-aſh, ſoda, ammonia, and alumine. Thoſe of zircon, ſtrontian, and glucine have not been aſcertained.

20. The oxalic acid decompoſes in part all the ſalts that have pot-aſh for their baſe, and forms in their ſolutions oxalic acidule, which is precipitated in ſmall cryſtals. By continuing to pour oxalic acid into theſe ſolutions, after having decanted them from each cryſtalline precipitation, we at laſt entirely decompoſe theſe ſalts, ſo great is the tendency which this acid has to take away pot-aſh from the other baſes. The ſame reſult is not ſo eaſily obtained with the ſalts of ſoda and ammonia, though they alſo experience a decompoſition, and yield part of their baſes to this acid. It decompoſes all the carbonates, and expels the acid from them with effervescence.

21. The oxalic acid acts upon ſeveral metallic ſubſtances, eſpecially thoſe that are capable of decompoſing water; it unites more or leſs eaſily with all the oxides of the metals; it even takes away ſeveral of them from the moſt powerful acids. Excepting tungſten, molybdena, chromium, uranium, titanium, and tellurium, which have not yet been combined with the oxalic acid, ſome properties of all the other combinations of this acid with the metals have already been indicated. The following is the ſummary reſult of the knowledge acquired upon this ſubject.

A. With the oxide of arſenic it forms ſmall priſmatic cryſtals, very fuſible, very volatile, and decompoſable by heat.

B. With the oxide of cobalt, a pulverulent ſalt, of a light roſe colour, little ſoluble.

C. With the oxide of biſmuth, a white ſalt in powder, very ſoluble in water.

D. With the oxide of nickel, a ſalt of a white or greeniſh yellow colour, very little ſoluble.

E. With the oxide of mangane∫e, a ſalt in a white powder, which blackens by the action of the fire.

F. With the oxide of antimony, a ſalt in cryſtalline tranſparent grains.

G. It acts upon metallic zinc with effervescence, and diſengagement of hidrogen gas; the water is decompoſed, and the oxidated zinc combines proportionally with the acid. This oxalate of zinc is in a white powder, and of an acerb taſte, though very little ſoluble.

H. It does not act upon metallic mercury; but it eaſily unites with its oxide, which it whitens by its contact. The oxalate of mercury is in a white powder, which quickly turns black when expoſed to the light. The oxalic acid precipitates the nitrate of mercury in a white powder; this precipitate, when heated, fulminates ſenſibly, according to the remark of Mr. Packen.

I. Poured upon tin, in plates or in filings, the oxalic acid firſt blackens it, and afterwards covers it with a white powder. The oxalate of tin, which is conſiderably ſoluble, has an auſtere and metallic taſte. When its ſolution is ſlowly evaporated, it yields cryſtals in the form of needles or priſms, ſufficiently well pronounced. When evaporated more violently, it affords a tranſparent maſs reſembling horn.

K. The oxalic acid quickly tarniſhes the brilliant colour of lead; it corrodes it; and diſſolves its oxide very well. When ſaturated with it, its condenſed ſolution depoſits ſmall brilliant cryſtals, which quickly become opaque by expoſure to the atmoſphere. The ſame acid decompoſes and precipitates the nitric ſolution of lead; if it be poured into this ſolution a little diluted, it affords cryſtals in the ſame manner as is done by the immediate union of the oxide of lead. They are alſo obtained by adding this acid to the ſolution of acetite of lead.

L. This acid ſtrongly attacks iron-filings; much hidrogen gas is diſengaged from the ſolution: in proportion as the decompoſed water furniſhes oxigen to the iron, this metal unites with the oxalic acid, and forms a ſolution which quickly becomes reddiſh, when heated or expoſed to the air. The oxalic ſolution of iron is very ſtyptic; it yields by evaporation priſmatic cryſtals of a greeniſh yellow colour. The ſame acid precipitates the ſuperoxigenated ſalts of iron, and eſpecially the red ſulphate of this metal, into an oxalate of a fine red colour, which ſome chemiſts have propoſed to be uſed in painting. There is no acid which diſſolves more quickly and more completely the black oxide of iron when in a ſtate of great diviſion, and eſpecially the gallate of iron. It is, therefore, employed with great advantage for taking out ink-ſpots, as well as its acidule, or the ſalt of ſorrel.

M. The oxalic acid alſo acts eaſily upon copper, and produces its green oxidation. It entirely diſſolves its different oxides. The oxalate of copper is of a light blue colour, little ſoluble. The ſame acid decompoſes and precipitates the ſulphate, the nitrate, the muriate, and the acetite of copper: the precipitate is a powder of a blueiſh-grey colour.

N. It does not attack metallic ſilver; but it diſſolves, though in ſmall quantity, the oxide of this metal precipitated from the nitric acid by pot-aſh. When oxalic acid is poured into the nitric ſolution of ſilver, we immediately obtain a white, thick, inſoluble precipitate of oxalate of ſilver. We obtain the ſame precipitate with any of the ſoluble oxalates united with the ſame ſolution of ſilver. This ſalt is very alterable by the action of light; by expoſing it to the rays of the ſun, it very quickly turns black. The oxalite of ſilver formed by this precipitation, when expoſed upon coals in a ſpoon, is diſperſed with a noiſe, and undergoes a kind of fulmination, according to the experiments of Mr. Packen, confirmed by Citizen Guyton.

O. The oxalic acid exerts no action upon gold, and it exerts very little even upon the oxide of this metal.

P. It diſſolves the precipitate of platina, formed by ſoda; without affecting the pure metal. The ſolution of oxalate of platina is yellowiſh, and affords cryſtals of the ſame colour.

22. It is to be remarked, that all the combinations of the oxalic acid with the metallic oxides that have been deſcribed by Bergman, from whom I have extracted the facts which I have preſented to the reader, after having verified moſt of them, and added to them ſeveral phenomena ſince diſcovered, are very eaſy to be decompoſed by the fire; that none of them affords even a trace of acetous acid in diſtillation, whilſt all thoſe of the citrates furniſh it conſtantly, and ſome of the latter frequently afford it in ſufficient quantity to enable us to ſubject it to experiments, and aſcertain its nature.

23. All the phenomena which the chemical properties of the oxalic acid preſent, prove, that this acid is more highly oxigenated than thoſe of which we have hitherto treated; that it is on this account that it cannot form other acids, or paſs into another acidified nature; that it is the laſt term of the vegetable acidification, and that it is no longer ſuſceptible, by any other oxigenated ſubſtance, or decompoſing proceſs, to be decompoſed other-

wiſe

Angelus Sala, Libavius, Zwelfer, Lefevre, Glazer, and Hierne maintained againſt many other chemiſts that tartar contained alkali ready formed. Duhamel and Groſſe, Margraff, and Rouelle the younger confirmed this aſſertion by very exact experiments. Meſſrs. Wiegleb, Rozenſteil, Packen, Bayen and Berniard gave or accumulated by different methods the proofs of the pre-exiſtence of the alkali in this acidule before the action of the fire. After Blaiſe de Vigenère, Lemery and Neumann, Spielman and Citizen Berthollet have well deſcribed the decompoſition of this acid by the fire; Corvinus, Citizens Machy and Berthollet, its ſpontaneous decompoſition in water; Scheele, Retzius, Bergman and Packen have given the means of extracting the pure acid from this acidule. Mr. Hermſtaedt has carefully examined ſeveral properties of this acid. Such is the ſummary reſult of the principal inveſtigations that have been beſtowed upon the tartarous acid.

2. Though the tartarous acid exiſts in the juice of the grape, in the tamarind, in ſumac, in the tamariſc, in balm, in the carduus benedictus, in the roots of reſt-harrow, of germander, of ſage, in the fruit of the barberry, and undoubtedly in a multitude of other fruits; it is not from theſe ſubſtances that it is extracted. It is more eſpecially precipitated and depoſited from wine kept in caſks, and particularly from the wines of France, and thoſe of the Moſelle and the Rhine. It forms ſucceſſive layers which become

condenſed almoſt like ſtony incruſtations, and which are collected upon the ſides of the barrels or caſks in which theſe liquors are kept. The white and red are diſtinguiſhed by the name of the *white* and the *red* tartar: but it is very far from being pure any more than the lees which contain a very large quantity of it. In tartar and in the lees, beſides the colouring matter which they contain, we alſo find foreign ſubſtances, kernels, ſkins, &c. We likewiſe find in them ſulphate of pot-aſh, &c. It is purified in order to ſeparate theſe foreign matters, by the following proceſſes, deſcribed by Fizes, Montet, and Citizen Deſmarets.

3. This acidule is in ſome meaſure refined or purified in the vicinity of Montpelier, in the manner in which in general many other ſaline ſubſtances are treated. The crude tartar is boiled in water; this boiling ſolution is filtrated; as it cools it becomes turbid, and depoſits irregular cryſtals in the form of a paſte. This paſte is boiled a ſecond time in copper veſſels, with water in which a fat earth dug at the village of Merviel, near Montpelier, has been diffuſed. The ſcum which riſes is carefully removed; afterwards a ſaline pellicle is formed, upon the appearance of which the application of the fire is diſcontinued; this pellicle is broken, and it precipitates itſelf with the cryſtals that have already been depoſited: theſe cryſtals are waſhed in water, in order to free them from the earth which ſoils them. They are introduced into

commerce under the very improper appellations of *cream* or *cryſtals of tartar*. The cream has been ſo called becauſe it is the part formed at the ſurface; the cryſtals or the ſalt of tartar are thoſe which are found beneath. It has been ſaid that the clay ſerves to free the tartar from the oily matter which was admitted to exiſt in it; but it is evident that it ſerves to ſeparate the colouring and extractive part, to which alumine, as we ſhall ſee hereafter, has a ſtrong attraction: accordingly this earth anſwers the ſame purpoſe here as in the purification of the ſalt of ſorrel; it diſcolors and clears the tartarous acidule by favouring its ſeparation, by even taking away its colouring matter.

4. At Venice, a ſomewhat different method is employed for purifying the tartar. According to Citizen Deſmarets, this acidule is diſſolved in the ſtate of powder, in boiling water; the foreign or impure ſubſtances which it contains are left to ſubſide, and the portion which floats above is taken off. The liquor yields cryſtals by reſt and cooling. Theſe cryſtals are again diſſolved in water which is ſlowly heated; when this ſecond ſolution boils, whites of eggs beat up in water and wood-aſhes paſſed through a ſieve are thrown in; this addition of aſhes is performed fourteen or fifteen times; the ſcum produced by the efferveſcence is removed, and the liquor is then left to reſt. A pellicle of very white ſaline cryſtals is ſoon formed upon it, the water is decanted and the ſalt dried. It is

very evident that this proceſs changes the nature of a part of the tartar or of the tartarous acidule, that the pot-aſh of the aſhes ſaturates a portion of its inſulated acid, as appears from the effervefcence which takes place; that part is converted into the ſtate of ſoluble tartar, and that much of it muſt be loſt by this proceſs. The mother water muſt contain tartrite of pot-aſh or *vegetable ſalt*, as it was formerly termed. It is equally evident that the Montpelier proceſs deſerves the preference.

5. Sometimes the tartarous acidule or the cream of tartar of commerce is purified in laboratories for chemical or pharmaceutical uſes. For this purpoſe it is boiled in water; the boiling ſolution is filtrated; it is left to cool ſlowly in veſſels of glaſs, earthen-ware or porcelain; and in this laſt purification the acidule is precipitated very white, cryſtalline, tranſparent, and extremely pure. This is the manner in which it ought to be prepared for medicinal uſe and for the accurate inveſtigations of chemiſtry.

B. Phyſical Properties.

6. THE tartarous acidule when ſufficiently pure is in ſmall cryſtalline fragments, the form of which is difficult to be determined with exactneſs. However, when we carefully obſerve the purification of this acidule, we diſtinguiſh needles, or quadrilateral priſms, truncated in a ſloping

direction at their extremity. Theſe priſms grouped together produce the irregular maſſes which form the common cream of tartar.

7. The taſte of this acidule is four, a little diſagreeable and not vinous like that of the crude or raw tartar, ſuch as it is taken out of the caſks. Its taſte is not nearly ſo acid as that of the oxalic acidule, and it does not ſet the teeth on edge as that does: accordingly it is not in general ſo antiſeptic as the latter, neither does it preſerve food equally well.

8. The tartarous acid is very brittle and pulverizable. As ſoon as it is heated to ſoftneſs and incipient fuſion, it changes its nature and is decompoſed as we ſhall ſoon ſee; it reddens the tincture of turnſole and the ſyrup of violets.

C. *Chemical Properties.*

9. WHEN the tartarous acidule is expoſed upon a burning coal, it becomes ſoft, fuſed, inflated, brown, emits ſour, pungent, empyreumatic fumes, of a particular and well determined ſmell: it leaves a voluminous, abundant, heavy, and very alkaline coal. The decompoſition of the tartarous acidule by diſtillation in a retort is one of the operations with which chemiſts have been moſt occupied, and upon the products of which they have amply written. This diſtillation is performed in a retort of ſtone-ware or caſt iron, to which are fitted an

adopter and receiver, provided with tubes proper for conducting and collecting the elaſtic fluids; the fire is applied by degrees and with precaution, and at laſt puſhed ſo far as to render the bottom of the retort perfectly red-hot. There firſt paſſes over water little coloured, and ſcarcely acid, afterwards a liquid acid ſtronger and reddiſh; then an oil which aſſumes colour and conſiſtence in proportion as the heat is increaſed, a large quantity of carbonic acid and carbonated hidrogen gas; and at laſt carbonate of ammonia which cryſtallizes in the adopter.

Amongſt all theſe products, each of which deſerves to be examined in particular, that which has moſt ſtruck the attention of chemiſts is the enormous quantity of elaſtic fluid, which they long conceived to be air. A cubic inch, or 543 grains of tartar of Rheniſh wine, gave Hales 304 inches, or 144 grains, or nearly one third of its weight of elaſtic fluid. Citizen Berthollet computes the quantity of gas extricated by diſtillation at nearly three quarters of the weight of the tartar. Spielman and Corvinus have calculated that this gas occupies two hundred and forty-four times the volume of the matter employed. Nearly three-fourths of this gas are carbonic acid, and one fourth carbonated hidrogen gas, which burns white or blue, and is mixed in two or three varieties, according to the quantity of carbon, or of intire oil, diſſolved in this gas.

The oil which forms, according to Lemery and Spielman, about one ſixth of the weight of the tartar, is one of the products of this diſtillation which differs the moſt from thoſe of the preceding acidule; it manifeſtly proceeds from the much larger proportion of carbon and hidrogen contained in the tartarous acid than in the oxalic. It was formerly rectified for the purpoſe of preparing a ſtrengthening external remedy, which was in high eſteem. It is evident that it did not exiſt ready formed in the tartar, but that it reſults from the particular union of a certain quantity of hidrogen and carbon; accordingly, it varies as well that as of the acid phlegm and the gaſes, according to the manner in which this diſtillation is conducted, and the rapidity and force of the fire that is applied.

Ammonia in the ſtate of concrete carbonate, indicated amongſt the products of this operation by Lemery, Juncker, Wiegleb, and eſpecially Bucquet, announces that the tartarous acidule contains azote amongſt its primitive principles. A portion, according to thoſe authors, is combined with the liquid acid, of which I ſhall ſoon ſpeak: but I muſt here obſerve that ſome modern chemiſts do not reckon ammonia amongſt the number of the products of the decompoſition of the tartarous acidule, and think that he was deceived by a ſmall quantity of pot-aſh, elevated at the ſame time as the liquids and the gaſes that are diſengaged. This fact, therefore, deſerves to be verified by new experiments more exact than thoſe that have hitherto been made; for it may lead us to determine whether it be not at the expenſe of the pot-aſh, as was formerly thought, that this volatile alkali is formed, and whether this fixed alkali does not furniſh azote which unites with the hidrogen of the decompoſed acid.

10. After this decompoſition, there remains in the retort a very alkaline and very acrid coal, which attracts the moiſture of the atmoſphere, which yields much carbonate of pot-aſh by mere lixiviation and cold water, and the nature of which ſerves to prove the preſence of this alkali in the proportion of one third of the weight of the tartar in the acidule; for at preſent it is no longer believed that the pot-aſh is formed by the action of the fire at the expenſe of the total decompoſition of the tartarous acid; for this, when pure, as we ſhall ſoon ſee, does not afford the alkali in its coal. Chemiſts avail themſelves of this property of the coal of tartar, in order to extract from it quickly and by an eaſy proceſs, a conſiderable quantity of ſufficiently pure pot-aſh Crude tartar is put, in the ſtate of a coarſe powder, into wrappers of thick brown paper, which are immerſed in water; theſe are placed upon a bed of charcoal in a furnace, which is thus ſucceſſively filled with alternate layers of papers of tartar and coal, care being taken to cover the laſt

layer with a ſomewhat thicker ſtratum of coal. This coal is ſet on fire, and ſuffered to become totally extinguiſhed after its complete combuſtion: when the whole has cooled, the papers are taken out much diminiſhed in volume, as is natural to ſuppoſe, but retaining their form, on account of the ſolidity of the paper and of the water which has agglutinated, and, as it were, united the leaves. Theſe papers contain the pot-aſh of the tartar, the coal of which is deſtroyed; it is combined with a portion of carbonic acid. Excepting a ſmall quantity of lime and ſulphate of pot-aſh, which are frequently found in this alkali, it poſſeſſes a conſiderable degree of purity. Formerly it was much employed by chemiſts, under the name of *fixed ſalt of tartar*, or alkali of tartar. As it contains much pot-aſh in an inſulated ſtate, it quickly attracts the moiſture of the atmoſphere, and then forms a thick liquid which was termed *alkali of tartar per deliquium*, oil of tartar *per deliquium*; this laſt ridiculous denomination has long been laid aſide. Three eighths of the tartar are obtained in this alkali.

11. One of the moſt remarkable products of this decompoſition of the tartarous acidule by fire, is the particular acid which paſſes in the liquid form in diſtillation, and which is a new production of the mutual re-action of the principles of the acid, effected by the action of caloric; this is the *pyrotartarous* acid. I ſhall ſpeak of it in detail, in treating of the tartar-

ous acid, which likewiſe affords it by diſtillation; it is ſufficient here to know that it is a modified acid, different from that which exiſted in the acidule, and which, compared with the other products of this igneous decompoſition, ſhows the great diverſity between this acidule and the oxalic acidule. Hence it may be concluded, that this decompoſition, which indicates a great abundance of carbon and hidrogen in the tartarous acidule, authorizes the termination in *ous*, adopted by the methodical nomenclature, and oppoſed to that of oxalic acidule; as this laſt, not being equally decompoſable is much more oxigenated.

12. The tartarous acidule experiences no alteration by the contact of the air; no ſimple combuſtible body, if we except carbon, which purifies or whitens it, exerts any action upon it. It is very difficult of ſolution in cold water, which ſcarcely takes up more than one ſixtieth part of its weight. Boiling water diſſolves nearly one thirtieth, the greater part of which is precipitated, and cryſtallizes by the cooling of the liquor. This ſolution, which is ſouriſh, and of a diſagreeable taſte, reddens the blue vegetable colours. When left to itſelf in a cloſe veſſel, it is decompoſed, and preſents phenomena very different from thoſe which I have deſcribed with reſpect to the oxalic acidule, which does not undergo the ſame decompoſition. Citizen Machy is the firſt who has ſpoken of this decompoſition, by which he

wiſhed to prove that the alkali was the product of an alteration, and that it was not contained ready formed in the tartarous acidule; but he was miſtaken when he aſſerted that the mucus that was precipitated did not contain alkali, and that the ſupernatant liquor was acid, ſince he has not purſued this decompoſition far enough, nor examined the ſupernatant liquor, which after this decompoſition contains the whole of the pot-aſh pre-exiſting in the acidule. Spielman and Corvinus have committed the ſame error, though they had made a more exact experiment. This ſpontaneous decompoſition has ſince been followed and deſcribed with the moſt care and ſucceſs by Citizen Berthollet; he has given the reſult in a Memoir inſerted amongſt thoſe of the Academy of Sciences, for 1782. After having diſſolved one part of tartarous acidule in ſixty-four parts of diſtilled water, he left this ſolution in a glaſs veſſel covered only with paper, in the natural temperature of his laboratory. The liquor gradually diminiſhed in volume; mucous flakes were precipitated in it, which he did not take away, like Spielman, in order that nothing might be loſt. At the end of five months this mucoſity was very abundant; the liquor was red, but it ſtill reddened the ſyrup of violets, and had a ſour taſte; the mucoſity ſtill augmented; he replaced the water which was evaporated, and after eight or nine months the liquor began to turn the ſyrup of violets green, aſſuming a more and more deep colour. After this ſpontaneous proceſs had been carried on for eighteen months, the liquor not appearing to him to undergo any more alterations, he filtrated it; the mucilage received upon the filtre dried there, loſing much of its volume, and being reduced to a very ſmall weight. After having burned it, its aſhes yielded only ſigns of alkalinity; but the ſupernatant liquid which was ſtrongly alkaline, afforded by evaporation carbonate of pot-aſh rather oily, and this being reduced to coal by the action of the fire, weighed five-eighths of the tartarous acidule originally employed; as did the alkali which he obtained by treating a like doſe of this acidule by diſtillation. According to the chemiſt whom I quote, the tartarous acid decompoſed ſpontaneouſly, and very ſlowly by this experiment, formed the mucous flakes that were precipitated, with the carbonic acid, and the ſmall portion of oil united with the pot-aſh that remained in the liquor, and exiſted ready formed in the acidule. I ſhall ſubjoin to this detail the reſult of another experiment adapted to confirm this theory, and leave no doubt of its accuracy; namely, that the pure tartarous acid, which is equally alterable by a ſlow and ſpontaneous decompoſition, leaves no pot-aſh in the liquor which is the reſiduum of its decompoſition, and that the ſolutions of the alkaline tartrites, in which we know exactly the proportions of alkalis that have been employed for preparing them, leave only theſe alkalis together with the carbonic acid and the ſmall quantity of oil, produced by the decompoſition of the acid.

13. The tartarous acidule, which I may equally term *acidulous tartrite of pot-aſh*, as the facts that have already been quoted reſpecting its properties, prove that it is in fact only tartrite of pot-aſh with exceſs of acid, experiences no alteration from any of the acids, unleſs they have ſufficient power to alter the peculiar nature of its acid. The portion of pot-aſh which it contains has more attraction for its exceſs of tartarous acid than any of the acids, even the ſtrongeſt have; and on this account the tartarous acid decompoſes all the alkaline ſalts till it becomes tartarous acidule. Accordingly, when in the experiments of Pott, of Margraff, and of Rouelle the younger, we find theſe able chemiſts ſucceed in extracting the pot-aſh from the tartar, or cream of tartar, by means of the acids termed *mineral*; we are to underſtand that they ſucceeded only by decompoſing the tartarous acid itſelf, and converting it either into acetous or oxalic acid. Thus by throwing one part of concentrated ſulphuric acid upon one part of tartarous acidule in the ſtate of powder, and favouring the action of this mixture, which becomes much heated at the moment when it is made, with the heat of a *balneum mariæ*, continued for ten or twelve hours: the two ſubſtances form a brown magma. By afterwards pouring into them

three or four times their weight of boiling diſtilled water, ſaturating the ſulphuric acid by means of chalk, filtrating and evaporating the liquor, we obtain ſulphate of pot-aſh mixed with a little ſulphate of lime. But what neither Rouelle nor Bernard have announced is, that acetous acid is formed in this experiment. The ſame circumſtance takes place by the muriatic acid. The nitric acid ſeizes the pot-aſh of the tartarous acidule only by cauſing its acid to paſs into the ſtate of oxalic acid.

14. The boracic acid unites without decompoſition with the tartarous acidule: one part of the firſt to four of the ſecond is ſufficient to render it ſoluble in ſix or eight times its weight of hot water, as Laſſone has ſhown in the Memoirs of the Academy for 1755. It is in this manner that we ought to prepare what has been termed in pharmacy *ſoluble cream of tartar*, and not with borax; for this laſt, which contains much ſoda in exceſs, as I ſhall ſhow on another occaſion, conſtitutes with the tartarous acidule a triple ſalt, a tartrite of pot-aſh and ſoda, mixed with boracic acid, which is very far from being *cream of tartar*. Accordingly, this addition of borax to cream of tartar for the purpoſe of rendering it ſoluble, announced by Lemery, in 1728, in the Memoirs of the Academy; and propoſed in the ſame year, as a remedy, by Lefebvre, phyſician at Uzés, in the ſame academical collection, cannot fulfil the in-

tentions of the phyſician, like that of the boracic acid alone.

15. Long ago ſeveral of the earthy and alkaline baſes have been combined with the tartarous acidule, in order more eſpecially to prepare from it different kinds of medicines. Chemiſts have examinated ſeveral of theſe combinations for better aſcertaining the nature and the properties of the tartarous acid; and their labours, as we ſhall ſoon ſee, have reciprocally enlightened the art of healing in the preſcription of theſe medicinal preparations: at leaſt, it is from the pharmaceutical ſource of theſe ſaline combinations, which are almoſt always triple, that the diſcoveries which have fixed their nature and properties, have been derived. We muſt therefore accurately deſcribe theſe combinations, conſidering them under the double point of view that has been indicated.

16. The ſolution of barites decompoſes that of the tartarous acidule, ſeizes its acid, with which it forms an inſoluble ſalt, which is precipitated in a white powder, and leaves the inſulated and pure part in the ſupernatant liquor: it is, as we ſee, a good mean of proving the preſence of pot-aſh in the tartarous acidule, and even of determining its proportion. The ſame is probably the caſe with ſtrontian.

17. Lime effects the ſame decompoſition, and even in a ſtill more energetic manner, ſince, according to the order of elective attractions indicated by Bergman, it is more attracted by

the tartarous acid than barites is. It is to be obſerved, that I do not intend here to deſcribe the properties of the earthy and alkaline tartrites, which are to be placed in the hiſtory of the pure tartarous acid; but that I only conſider the action of theſe baſes, as decompoſing the tartarous acid, and uniting with it into triple ſalts. When lime-water is poured into a ſolution of tartarous acidule, an abundant and pulverulent precipitate of tartrite of lime is produced, and pure pot-aſh remains in the liquor. If we take carbonate of lime, as Rouelle has done, this earthy ſalt acts only upon the free portion of the tartarous acid, with which it alſo forms inſoluble calcareous tartrite in proportion as carbonic acid is diſengaged. After this, the ſupernatant liquor contains the portion of pure and neutral tartrite of pot-aſh, with which the tartarous acid was united in the acidule. This is another of thoſe ſimple and ingenious experiments by which Rouelle the younger proved in an immediate manner the preſence of pot-aſh in tartar. He thus ſeparated from it the neutral ſalt which was termed at that time *vegetable ſalt*, and of which I ſhall ſpeak in detail in the article concerning the tartarous acid.

18. Magneſia does not act in the ſame manner upon the tartarous acidule. Though Bergman places it before the fixed alkalis, in his order of attractions for the tartarous acid, it does not appear to be capable of ſeparating the

pot-aſh from this acidule, but rather of remaining united with the acid at the ſame time with it, and of forming a kind of triple ſalt. The Chemiſts of the Academy of Dijon have obtained from the acidulous tartrite of pot-aſh, ſaturated with magneſia, a ſoluble ſalt, which yielded them, by its ſpontaneous evaporation, ſmall aculeated cryſtals, diſpoſed in rays. Poulletier de la Salle has obtained from the ſame combination a gelatinous maſs, reſembling a mucilage.

19. It appears that alumine produces a nearly ſimilar effect with the tartarous acidule, though it unites with it with more difficulty, ſince, as we have ſeen above, argil is employed to purify tartar in the vicinity of Montpelier. The action of zircon and glucine upon this acidule is abſolutely unknown. Silex does not ſeem to exert any upon this ſaline compound.

20. When we combine pot-aſh or the carbonate of pot-aſh with the tartarous acidule, it becomes ſaturated entirely with this alkali, and forms the ſame ſalt as that which ſhall be deſcribed by the name of tartrite of pot-aſh, in the hiſtory of the tartarous acid.

21. The ſame is not the caſe with ſoda as with pot-aſh: this alkali, by combining with the tartarous acidule which it ſaturates completely, forms with it a kind of triple ſalt, which has long been named *Salt of Seignette*, from the name of a pharmaceutical practitioner of Rochelle, who firſt diſcovered, prepared, and

propoſed it for medicinal uſe. As a *triſule*, namely, *tartrite of pot-aſh and ſoda*, the hiſtory of this ſalt muſt here be explained.

In order to prepare this ſalt, one part of ſufficiently pure tartarous acidule is thrown into five parts of boiling water, and to theſe is added carbonate of ſoda cryſtallized and reduced to powder, till no more effervefcence takes place, and till the acidule is completely ſaturated. In proportion as this ſaturation is effected, the acidule diſappears and diſſolves in the liquor; after having drawn it off clear, this is evaporated to the conſiſtence of a thin ſyrup, and ſuffered to cool gradually: by this gradual cooling it furniſhes large and very regular cryſtals, in priſms of eight ſides nearly equal, which are frequently excavated, as it were, in their middle and almoſt in their axis; they then reſemble a tomb. The broad face upon which they reſt then preſents two diagonal lines which croſs each other at the centre. This ſalt, which at firſt was ſold as an arcanum, was diſcovered in 1731, by Boulduc and Geoffroy, who deſcribed its preparation in the ſittings of the Academy of Sciences of Paris. Since this period all druggiſts have prepared it in their laboratories; it has become much more common and conſequently much better known.

When this ſalt is prepared, as well as the tartrite of pot-aſh or vegetable ſalt, there remains at the bottom of the liquor a kind of earthy reſiduum, in the form of clay or paſte, ſometimes in that of ſmall needles interwoven with each other. The practitioners of pharmacy, who all know this depoſition, had conſidered it as a ſpecies of earth engaged in the *cream of tartar* of commerce, and ſeparated by the ſoda. Citizen Vauquelin has examined it with care; he has found that it forms about 0,07 of the tartarous acidule, that it is not ſeparated from the pure tartarous acid, that it exiſted only in the *cream of tartar*, and that it is tartrite of lime afforded by the wine; as he has alſo found it in crude tartar. He has ſhown by the ſame inveſtigation, that the ſalt of Seignette contains very nearly 0,54 of tartrite of pot-aſh, and 0,46 of tartrite of ſoda; that thus it is accurately termed *tartrite of pot-aſh and of ſoda*. This triple ſalt has a bitter taſte; it is decompoſed by the fire, and yields pyrotartarous acid, oil, and gas, like all the tartrites; it effloreſces in the air; it is ſoluble in about five parts of water; it is decompoſable in part by the powerful acids which precipitate from it the tartarous acidule; it is entirely decompoſable by barites and by lime.

22. The tartarous acidule combines alſo with ammonia, which ſaturates it into a triple ſalt. This tartrite of pot-aſh and of ammonia affords fine cryſtals, which Bucquet has deſcribed as pyramids; Macquer, as hexahedral priſms, terminated by very ſharp pyramids; the academicians of Dijon as parallelopipedons with two alternate ſlopes. It has a cooling taſte;

It is decompoſed by the action of fire; it effloreſces in the air; it is more ſoluble in hot than in cold water, and cryſtallizes by cooling. The acids precipitate acidule from it; lime, barites, ſtrontian and the fixed alkalis ſeparate from it either both baſes, or only ammonia.

23. Though, in general, there is little reciprocal action known between the ſalts and the tartarous acidule, it is probable that there would take place between them, eſpecially thoſe with an earthy baſe, a great number of effects of double attractions, which it would be uſeful to appreciate. The nitrates and the ſuperoxigenated muriates decompoſe it with the aſſiſtance of heat, decompoſe or burn its acid, more or leſs completely according to the proportion of theſe ſalts which is added to it. With the nitrate of pot-aſh and crude tartar is prepared an alkali, or rather a carbonate of pot-aſh, which was formerly termed in chemiſtry *white flux*, or *black flux*, accordingly as the one contained only the alkaline carbonate by reaſon of the complete combuſtion of the carbon, and as in the other there remained a portion of the carbon of the tartar. Theſe names of fluxes have been given to the products of theſe operations, becauſe they have been eſpecially deſtined to ſerve for fuſing the earths of the gangues in the aſſaying of ores. The black or reducing flux is formed with two parts of tartar and one part of nitre; the white with equal parts of tartar and of nitre, the mixtures being thrown into a red-hot cruci-

ble, in which they detonate and inflame with rapidity. The combuſtion and detonation of the ſecond is much ſtronger than that of the firſt. The term of *crude flux* is applied to the mixture of nitre and of tartar in whatever proportions before it has been made to detonate.

24. The tartarous acidule appears to be capable of uniting with moſt of the metals, and eſpecially of the metallic oxides, without being decompoſed, according to the experiments of Citizen Monnet and the academicians of Dijon. It conſtitutes a kind of triple ſalts. Hitherto thoſe only have been examined with attention that take place with the oxides of antimony, of mercury, of lead and of iron; either becauſe theſe compounds preſent a greater number of remarkable facts, or becauſe moſt of them are medicines of more or leſs importance; that which merits the moſt attention of all, which is ſo generally employed that it might be ſaid to conſtitute a kind of univerſal remedy, is its union with the oxide of antimony.

25. The names of *ſtibiated tartar*, *antimoniated tartar*, *tartar emetic*, have been applied to the triple ſaline combination of the tartarous acidule, and the oxide of antimony. Adrian de Mynſicht was the firſt who gave an account of it, in 1631. Almoſt all chemiſts have zealouſly occupied themſelves with it; but none of them have examined its properties with more attention than Bergman. Every author and every pharmacopoeia has given particular

proceſſes for preparing this important medicine. They differ from each other, both with reſpect to the ſpecies of oxide of antimony which they propoſe, with reſpect to their quantity, and that of the water, or of the tartarous acidule, and laſtly with reſpect to the manner of proceeding in its preparation. Bergman, in his Diſſertation, has given a very well conſtructed table of all the proceſſes hitherto deſcribed for this preparation. The ſublimed white oxides and the vitreous ſulphureous oxides have been ſucceſſively recommended. Some have preſcribed ebullition with the tartarous acidule and water for the ſpace of ten or twelve hours; others have indicated only an ebullition of half an hour. Some have recommended to evaporate the filtrated lixivium to dryneſs; others have preſcribed to cauſe it to cryſtallize, and to uſe only the cryſtals. Accordingly as theſe different proceſſes have been adopted in different pharmaceutical laboratories, ſalts very different in their nature and their virtues have been obtained. Thus Geoffroy by examining different ſtibiated tartars, found them to contain from one-eighteenth to upwards of one-fourth of their weight of oxide of antimony. After a great number of trials, moſt able chemiſts have preferred the vitreous ſulphurated oxide of antimony, or the *glaſs of antimony*, to all the other oxides, as it is one of the moſt ſoluble by the tartarous acidule. It is boiled with an equal quantity of tartarous acidule, both reduced to powder, in a ſufficient quantity of water, namely, eight or ten times their weight, till the acidule is ſaturated; there riſes a conſiderably thick ſcum, charged with yellowiſh or brown flakes, which are a mixture of ſulphur, of tartrite, of lime, and of a little oxide of antimony. Frequently this ſcum forms a magma, as it were gelatinous, which yields a pyrophoric reſiduum when diſtilled. The liquor, which is of a very clear lemon colour, is filtrated; then evaporated with a gentle heat till a ſlight pellicle is formed, and ſuffered to cool ſlowly; regular cryſtals are formed, which are extracted from it at ſeveral times by ſucceſſive evaporations. Some chemiſts prefer the oxide of antimony precipitated from the ſublimed muriate by water, or the grey ſulphurated oxide, for this preparation.

26. This compound is a triple ſalt, or a tartrite of pot-aſh and antimony, which cryſtallizes in regular tetrahedrons or triangular pyramids, or in octahedrous more elongated than thoſe of alum. It has a ſlightly metallic and harſh taſte: fire decompoſes it, diſengages from it pyrotartarous acid, and leaves a coal which contains pot-aſh and oxide of antimony, and which frequently takes fire by the contact of the air. This ſalt effloreſces in the air, loſes its tranſparency, and becomes of a dull white colour, very brittle and pulverulent. It is ſoluble in eighty parts of water at fifteen degrees. Boiling water diſſolves above one half more of

it. The ſolution ſlightly reddens the tincture of turnſole. The earths and the alkalis ſeparate from it a very white oxide of antimony: the alkaline carbonates, a carbonate of antimony in ſmall needled cryſtals, diſpoſed in rays. The alkaline ſulphurets and the hidro-ſulphurets form in it a precipitate of an orange colour, or a *ſulphur auratum*, the colour of which renders it eaſy to recognize the preſence of this antimoniated ſalt. The juices of plants, and eſpecially the extractive decoctions of the woods, the roots and the barks, precipitate the ſolution of tartrite of pot-aſh and antimony into a matter of a reddiſh-yellow colour, which has no longer an emetic quality; and Citizen Berthollet has propoſed to deſtroy, by means of a decoction of Peruvian bark, the bad effects of this ſalt received in too large quantity, or inconſiderately into the ſtomach. Several metals, and particularly iron, decompoſe the tartrite of pot-aſh and of antimony, and precipitate the latter oxide. Bergman aſſerts that it contains nearly a third of its weight of antimony.

27. The tartarous acidule may be combined in two ways with the oxide of mercury; for it has only a feeble action upon this metal, of which it only favours the oxidation into the black ſtate, or the ſimple extinction. The firſt conſiſts according to the proceſs of Citizen Monnet, in treating with boiling water, ſix parts of tartarous acidule, and one part of oxide of mercury

precipitated from the nitric acid by the carbonate of pot-aſh. The filtrated liquor yields by evaporation ſmall cryſtals of tartrite of pot-aſh and of mercury. However this ſalt is of little permanency, for the ſame author aſſerts that it is ſuſceptible of being decompoſed by pure water. The ſecond method conſiſts in pouring a ſolution of tartrite into the nitric ſolution of mercury; but here only a ſimple tartrite of mercury is precipitated, and no triple ſalt is formed, as in the preceding caſe; the compound formed, belongs therefore to the hiſtory of the tartarous acid, not to that of the acidule.

28. A very ſenſible action takes place between the tartarous acidule and the oxides of lead. Rouelle the younger, has verified, that theſe oxides have the property of decompoſing the tartarous acidule, of taking from it its exceſs of acid, and of uniting with it into a tartrite of lead, white, pulverulent, and inſoluble; of leaving in the ſupernatant liquor the tartrite of pot-aſh, which exiſted in the tartarous acid: accordingly this chemiſt has employed this fact for confirming the preſence of pot-aſh in this acidule.

29. It appears, that the tartarous acidule eaſily attacks copper and its oxides, and that the reſult is a triple ſalt of a fine green colour, ſuſceptible of cryſtallization, which has hitherto been but little examined.

30. Iron is one of the metals upon which this acidule acts with the moſt energy, and with

which it forms ſeveral compounds deſigned for medicinal uſe. The *chalybeated tartar* is prepared by boiling in 92 parts of water, four parts of iron filings, and ſix parts of tartarous acidule. When the acidule appears to be diſſolved, the liquor is filtrated; it depoſits cryſtals, and others are obtained from it by continuing the evaporation. The *tartarized tincture of Mars* is the product of a paſte made with ſix parts of iron filings ſixteen parts of tartarous acidule, and a ſufficient quantity of water, which is left at reſt for twenty-four hours, and is afterwards boiled in 92 parts of water for two hours, till it is evaporated to the conſiſtence of a ſyrup, one part of alcohol being added at the end. It appears that this latter medicine is not a triple ſalt, as Rouelle aſſerts, but that the pot-aſh exiſts in it in a free ſtate, and that by treating it with the acids it affords the ſalts which that alkali always yields. There are alſo prepared what are termed *ſteel-balls* (*boules de Mars*), by putting one part of ſteel-filings, and two parts of white tartar, in the ſtate of powder, into a glaſs veſſel with a certain quantity of ſpirit of wine. When this is evaporated, the maſs is pounded, ſpirit of wine is added, as at firſt, and it is left to dry. This proceſs is repeated till the mixture becomes fatty and tenacious: it is then formed into balls.

D. *Uses.*

31. The tartarous acidule, under the form of crude tartar, white or red, is employed in many of the arts, eſpecially in dyeing, in the felting of hats, in gilding, in docimaſtic proceſſes, &c. In chemiſtry it is an extremely uſeful ſubſtance, as I have already ſhown.

32. In medicine, the purified tartar, or the tartarous acidule, is much employed under the name of *cream of tartar*, as a refrigerant, an antiſeptic, and a gentle purgative. It is frequently rendered ſoluble by the addition of borax, or boracic acid. It cannot be employed as a condiment, on account of its diſagreeable taſte. However it is uſed at table in the Northern countries, where it is ſaid to be conſumed in large quantities. Moſt of the products or the triple ſaline compounds, formed by the tartarous acidule, are alſo medicines more or leſs ſerviceable, and in uſe.

SPECIES II.

VARIETY II.

Of the Tartarous Acid.

A. *Hiſtory, Extraction:*

1. SCHEELE firſt taught chemiſts the means of extracting the tartarous acid from tartar, and ſeparating it from the portion of pot-aſh, which it contains in its ſtate of acidule. He communicated his proceſs to M. Retzius, who publiſhed it in the Memoirs of Stockholm for 1770. It is the firſt diſcovery that is known of this able Swede. Any given quantity of acidulous tartrite of pot-aſh is diſſolved in boiling water; carbonate of lime is thrown in till no more efferveſcence takes place, and till the liquor no longer reddens the ſyrup of violets. The liquor is ſuffered to cool, and filtrated; in this manner inſoluble tartrite of lime is ſeparated in a white powder, which remains upon the filtre; it is then evaporated, and by evaporation nearly the half of the weight of the acidule employed is extracted in tartrite of pot-aſh, or vegetable ſalt. The tartrite of lime, being well waſhed, is put into a large glaſs cucurbit; a quantity of ſulphuric acid, equal to that of the chalk employed, and diluted with half its weight of

water, is poured upon it. This mixture is digeſted in a ſand-bath for twelve hours, ſtirring it from time to time with a ſpatula of wood or glaſs. The ſulphuric acid ſeizing the lime, forms a ſulphate which is precipitated in the place of the inſoluble tartrite, and the ſupernatant liquor contains the tartarous acid free. This is decanted, and after the precipitate has been well waſhed, and this lixivium mixed with the firſt liquid, it is tried by the acetite of lead, which forms in it a precipitate entirely ſoluble in vinegar, if the tartarous acid be pure, but not ſoluble, if it be mixed with ſulphuric acid. In the latter caſe, it is digeſted again upon a little tartrite of lime, in order to take away the ſulphuric acid that may be contained in it. It is then evaporated, and a little more than one third of the weight of the acidule employed is obtained in concrete tartarous acid.

2. It is probable that this acid exiſts pure in ſome vegetables, as Citizen Vauquelin has found about one ſixty-fourth of it in the pulp of the tamarind; but it is ſo little abundant, and ſo much enveloped, as it appears, that we cannot yet hope to find means of obtaining it in a direct way, till it ſhall be aſcertained that there exiſt plants, or parts of plants, in which it is contained in greater abundance than in thoſe from which it has been extracted, or rather which have hitherto preſented ſome traces of it.

3. Several modern chemiſts have ſpoken of the converſion of ſome vegetable ſubſtances, and even of ſome vegetable acids into tartarous acid; but this has not yet been confirmed by experience; beſides which, they have yet prepared ſo little of it by this artificial proceſs, that it has not hitherto been poſſible to employ this method for obtaining the acid in queſtion.

4. It is to be obſerved, with reſpect to the proceſs of Scheele, the only one that has yet been practiſed for obtaining the tartarous acid free and pure, that lime may be employed inſtead of chalk; and that then all the tartarous acid being abſorbed by this earth, we obtain more of it on the one hand; and on the other there remains in the liquor which ſwims above the tartrite of lime only, pure and cauſtic potaſh. In order to obtain this acid ſufficiently pure, the firſt cryſtals are diſſolved again in diſtilled water, and this ſecond ſolution is evaporated to cryſtallization.

B. *Phyſical Properties.*

5. The tartarous acid extracted by the proceſs of Scheele has the form of cryſtals, moſt frequently in very fine needles, reſembling hairs. Bergman has repreſented them like leaves collected together at one of their extremities, and divergent at the other. Spielman and Corvinus have obtained cryſtals by cooling, grouped together in the form of plates, ſome in

needles, others in pyramids. By a ſlow evaporation of the ſaturated ſolution, I have obtained it in irregular hexahedral priſms, but however ſufficiently well pronounced. Slow and ſpontaneous evaporation yields it in ſquare plates a little rhomboidal with oblique edges.

6. It has a very acid and very pungent taſte, which ſtrongly ſets the teeth on edge, and which is not diſagreeable, like that of the tartarous acidule. Diluted with water, it has a taſte reſembling that of lemon-juice, and may be employed for preparing a good lemonade. It ſtrongly reddens the blue vegetable colours, and is not fuſible without alteration.

C. *Chemical Properties.*

7. When expoſed to the fire upon ignited coals, the tartarous acid is fuſed, becomes black, emits fumes, ſwells, exhales a pungent acid vapour, burns with a blue flame, and leaves a ſpongy coal, in which are found ſome traces of lime. When diſtilled in a proper apparatus, it affords water charged with pyromucous acid, coloured oil, much carbonic acid and carbonated hidrogen gas; it leaves a voluminous ſwelled coal, which yields no pot-aſh, a certain proof that this alkali is not formed at the expence of the principles of the tartarous acid in the diſtillation of the tartarous acidule, from the reſults of which it differs only in the abſence of am-

monia in its products and of pot-aſh in its reſiduum. Spielman and Corvinus who have carefully diſtilled four ounces of this acid, concrete and cryſtallized in the pneumato-chemical apparatus, have obtained 431 cubic inches of carbonic acid gas, and 120 inches of carbonated hidrogen gas.

8. Amongſt the products of this decompoſition of the tartarous acid by fire, that which characterizes it the moſt, and belongs to it in a ſpecific manner, is the acid water which is obtained in the ſame manner as from the acidule. This is the pyrotartarous acid, the diſtinctive properties of which I ſhall here enumerate. The tartarous acid furniſhes more of it than the acidule; it amounts to at leaſt one-fourth of the weight of the firſt; it is a reddiſh liquor which is ſeparated from the oil by the funnel. It cannot be rectified by diſtillation without breaking the retort, by the kind of exploſion which it preſents, according to the academicians of Dijon. It has a ſlightly ſour taſte, and produces a diſagreeable impreſſion upon the tongue. It is ſtrongly empyreumatic; it reddens turnſole, but not the tincture of violets; it diſengages the carbonic acid from the earthy and alkaline carbonates with energy; it forms with the alkalis ſoluble and cryſtallizable ſalts. Its ſaline combinations are not well known, neither are thoſe which it is capable of affording with the oxides of the metals; it precipitates the nitric ſolution of ſilver in a white-grey powder;

that of mercury in a white powder, which is but ſlowly depoſited; that of lead, likewiſe white. The attractions of the pyro-tartarous acid are not yet known; and the little that is hitherto known of its properties is merely ſufficient to diſtinguiſh it from all the other acids, and to ſhow that it is neither the nitric nor the muriatic acid, as was at firſt imagined by ſome chemiſts. It is only evident that this acid is a ſimple modification of the tartarous, that, like it and the other vegetable acids, it is compoſed of carbon, hidrogen, and oxigen, and that it differs from it by the proportion of its principles, and eſpecially by the larger quantity of hidrogen.

9. The tartarous acid is not altered by the action of the air; it is much more ſoluble in water than its acidule, as Bergman has made a ſolution of it, the weight of which was to that of water as 1230 to 1000. It is obtained ſeparate and cryſtallized by the evaporation of its water of ſolution, whether this be effected by artificial means, or ſuffered to take place ſpontaneouſly. This ſolution is not altered nor decompoſed ſpontaneouſly except when it is diluted with water; when concentrated, it loſes nothing of its acid nature or of its properties.

10. Bergman believed that the tartarous acid was unalterable by the powerful mineral acids, and eſpecially by the nitric acid; but Mr. Hermſtaedt has effected its converſion into

oxalic acid, by diſtilling it ſeveral times ſucceſſively with ſix times its weight of nitric acid; 360 parts of tartarous acid afforded him 560 parts of cryſtallized oxalic acid; which indicates the fixation of a large quantity of oxigen.

11. The tartarous acid forms with barites and lime inſoluble, pulverulent, white ſalts, which are, however, diſſolved by the aid of an exceſs of their acid, and are decompoſed by the mineral acids. Theſe two baſes have not only more attraction with the tartarous acid than all the others, but Bergman places magneſia before the alkalis in his table of elective attractions. The tartrite of lime ſerves, as we have ſeen, for extracting the tartarous acid by means of the ſulphuric acid.

12. The combination of the tartarous acid with magneſia and alumine yields no cryſtallizable ſalts but gelatinous or gummy maſſes. Citizen Vauquelin, by examining the ſulphate of ſtrontian found at Bouvron in the department of la Meurthe, and the combinations of the baſe which he has extracted from it, ſays that the tartrite of ſtrontian formed by the union of the muriate of this earth with the tartrite of potaſh, is ſoluble, and cryſtallizes by the heat of ebullition, that it contains 52,88 of ſtrontian and 47,12 of acid.

13. When we unite tartarous acid with potaſh, ſoda or ammonia, employing a proportion of the baſe leſs than is required for its

ſaturation, there is precipitated in the three combinations an inſoluble acidule, which each of the baſes has the property of forming. The differences which each of theſe acidules preſents have not yet been examined; and their analogy has only proved that the tartarous acid, in its ſemi-ſaturation by each alkali, becomes infinitely leſs ſoluble than the acid alone is, or its entirely ſaturated combination with any of theſe three alkalis. Theſe acidules all reſemble each other in being equally decompoſable by the powerful acids, all which have leſs attraction with the alkalis than the tartarous acid has with the firſt portion that unites with it.

14. The tartarous acid, combined with potaſh, and entirely ſaturated, forms a ſoluble ſalt, which was formerly termed *ſoluble tartar*, or *vegetable ſalt*, and which is deſignated in the new nomenclature by the name of *tartrite of pot-aſh*. We have ſeen above that the tartarous acidule, which is merely tartrite of pot-aſh with exceſs of acid, affords the ſame ſalt by the addition of pot-aſh: I have already indicated it, and have announced that I ſhould ſpeak of it in the hiſtory of the tartarous acid. I ſhall, therefore, here explain its principal properties. It is prepared by throwing tartarous acidule into a hot ſolution of carbonate of pot-aſh: a lively efferveſcence takes place by the diſengagement of carbonic acid. Acidule is continued to be thrown in, till the liquor is ſaturated, and no

longer produces any efferveſcence; it is boiled for the ſpace of about half an hour; then filtrated, and afterwards evaporated to the formation of a pellicle, and ſuffered to cool ſlowly; cryſtals are formed in it in long ſquares terminated by two oblique faces. This ſalt has a bitter taſte; it fuſes, ſwells and blackens upon ignited coals. It yields pyromucous acid, oil, and much gas by diſtillation; it leaves a large quantity of alkali in its coal; it attracts in a ſmall degree the humidity of the atmoſphere; and is ſoluble in four parts of water at forty degrees. Its ſolution when kept for ſome time is decompoſed, depoſits mucous flakes, and leaves oily carbonate of pot-aſh in the water. Lime, barites, ſtrontian, and probably magneſia decompoſe it. The three firſt baſes form in it an abundant precipitate. The mineral acids ſeparate from it the exceſſive portion of pot-aſh beyond the ſtate of acidulous tartrite, and precipitate this acidule from its ſolution; heated with it for a long time and violently, they take from it the whole of the pot-aſh by altering its acid: it decompoſes moſt of the metallic ſolutions. The tartarous acid, added to the ſolution of tartrite of pot-aſh, changes it into tartarous acidule which is quickly depoſited in ſmall cryſtals.

15. The ſaturated combination of tartarous acid and ſoda, or the pure tartrite of ſoda, is much leſs ſoluble than the ſalt of Seignette or the triple tartrite of pot-aſh and ſoda; it cryſtal-

lizes in very fine needles or in thin plates, and not in large priſms of eight ſides like the latter. Beſides this is proved not to be the real ſalt of Seignette by the circumſtance, that when a ſolution of tartrite of pot-aſh is mixed with a ſolution of this pure tartrite of ſoda, provided that both have been concentrated without, however, cryſtallizing, we immediately obtain cryſtals of this ſalt of Seignette, or of tartrite of pot-aſh and ſoda in priſms of eight ſides, like thoſe of this triple ſalt.

16. The ammoniacal tartrite, or the tartarous acid ſaturated with ammonia cryſtallizes well. This bitter ſalt is very ſoluble and decompoſable by fire, by barites, ſtrontian, lime, magneſia, and the two fixed alkalis. The powerful acids precipitate from it an acidulous ammoniacal tartrite. Its ſolution is alſo ſpontaneouſly decompoſable with the aid of lime.

17. The tartarous acid decompoſes all the alkaline ſalts, and takes from them the portion of pot-aſh, of ſoda and of ammonia which it requires for forming acidules. It precipitates the nitrate, the muriate, and the acetite of lime from which it ſeparates this earthy baſe. It is evident that it is by no means ſo weak as was formerly believed, ſince it has more ſtrength than the mineral acids.

18. There are but very few metals upon which it exerts an immediate action; but it unites with the moſt of their oxides.

A. The tartrites of arſenic, of tungſten, of molybdena, of chromium, of titanium, of uranium, of cobalt, and of nickel, are not yet known.

B. It forms with the oxide of mangaueſe, from which it diſengages a portion of the oxigen, a limpid ſolution.

C. It does not act upon antimony, even with the aid of heat; it combines well with its oxides, eſpecially the vitreous ſulphuret or glaſs of antimony, and the powder of Algaroth; it forms a tartrite of antimony, which cryſtallizes but very little, very irregularly, and which yields, for the greater part, a gelatinous matter: whence it follows that this combination, ſo different from the antimoniated tartrite of pot-aſh, cannot be ſubſtituted in its place.

D. It has no effect upon biſmuth, but it takes its oxide from the nitric ſolution, and forms a tartrite of biſmuth precipitated in a white and inſoluble powder.

E. The tartarous acid, when triturated dry or liquid with mercury, favours its extinction, or its oxidation into the black ſtate. It unites with its red oxide which it whitens; it decompoſes and precipitates the nitrate of mercury, and forms, with its oxide, an inſoluble tartrite of mercury, which quickly becomes yellow by the contact of the air and of light. It acts neither upon the ſulphate nor the muriate of this metal.

F. It attacks zinc in an active and powerful manner, which preſents, by its contact a rapid efferveſcence and diſengagement of hidrogen gas. The tartrite of zinc which is formed has not yet been examined.

G. It has no direct action upon tin, or upon lead, though it appears to combine with their oxides. It whitens, by mere contact, the red oxide of lead. It decompoſes and precipitates the nitrate and the muriate of the latter metal into a white inſoluble tartrite.

H. It acts upon iron as upon zinc, diſſolves it with efferveſcence and diſengagement of hidrogen gas, and affords a red ſolution which aſſumes the form of a gelatinous maſs without cryſtallizing. Poured into the ſolution of ſulphate of iron, it does not precipitate it; but when the mixture is heated, according to M. Retzius, it ſeizes the portion of oxide which detaches itſelf from this ſalt, and forms with it lamellated cryſtals, little ſoluble, which, according to the ſame chemiſt, are not precipitated by the pruſſiates, unleſs acid of nitre is added.

I. Without ſenſibly altering copper by its firſt contact, it unites with its oxides and forms a ſalt of little ſolubility, of a green colour. Mr. Parker has obſerved ſmall, green, irregular cryſtals formed at the bottom of the nitric and muriatic ſolutions of copper, into which he had poured tartarous acid, which had produced no ſenſible effect at the firſt moment when it was mixed with them.

K. It does not attack ſilver, or gold, or platina, nor does it precipitate the nitric ſolution of the firſt, or the nitro-muriate of the ſecond. However, the ſaturated ſalts effect theſe precipitations, like that of all the other metallic ſalts, by a double attraction.

L. In general all the metallic tartrites, moſt of which are pulverulent and little ſoluble, yield pyrotartarous acid by diſtillation, are decompoſed by the earths and the alkalis, form many triple tartrites, by the addition of a ſmall proportion of the latter, and always yield their oxides to the ſulphuric acid, ſometimes to the muriatic, rarely to the nitric. None of them have yet been employed.

19. The tartarous acid is one of the ſtrongeſt vegetable acids; it yields only to the oxalic acid. Compared with the other vegetable acids, it appears more eſpecially to differ from them by the proportions of its principles, and eſpecially by that of the carbon. Citizen Vauquelin and myſelf have found in our analyſes, that 100 parts of this acid contain 70,5 of oxigen, 19 of carbon, and 10,5 of hidrogen. Hence it appears to follow, that in order to convert it into oxalic acid, it is only requiſite to take from it 6 parts of carbon, and to add to it 6,5 of oxigen, without at all changing its proportion of hidrogen, which is the ſame as in the oxalic acid.

D. *Uſes.*

20. NOT much uſe has has yet been made of the pure tartarous acid, though known ſince 1770: it has hitherto been prepared, almoſt excluſively, in the laboratories of chemiſtry, in order to determine its properties and nature. It may, however, be employed as a cooling, antiſeptic, and antifebrile drink; and, in the *War of Liberty*, a pretty conſiderable and very advantageous uſe was made of it in the military hoſpitals of the French Republic. Diluted with water, and ſweetened with ſugar or honey, it forms a very agreeable and wholeſome kind of lemonade—a convincing proof that the faint and unpleaſant taſte of the tartarous acidule depends intirely upon its ſemi-ſaturation with pot-aſh. As this acid may become ſo uſeful an object, it is eſſential to add an improvement, ſmall indeed, but uſeful, to the art of refining the tartar, to that of preparing pharmaceutically its ſaline and medicinal combinations. It has been ſeen that there is ſeparated, in theſe operations, at leaſt 0,07 of cream of tartar, and conſequently a much larger quantity of tartrite of lime in an inſoluble powder, or a viſcous paſte of tartar, and that this matter has been well examined by Citizen Vauquelin. It will henceforth be adviſable to collect it in the abovementioned operations, to waſh it well, to treat it with the ſulphuric acid diluted with water, and to extract from it the pure tartarous

acid, which will be eaſily kept, and exhibited in the ſolid and cryſtalline form, or by giving it the nature of a ſyrup with the addition of ſugar, it may be ſubſtituted in place of the ſyrup of lemons.

SECTION IV.

Of the Third Genus of Vegetable Acids, or of the Empyreumatic Acids.

1. I HAVE already ſhown that a great number of vegetable ſubſtances, heated in cloſe veſſels, yield by diſtillation, acid liquors which did not exiſt in theſe ſubſtances previous to the action of the fire, and that this agent really produces them. It is not neceſſary here to return to the explanation of this phenomenon, or to repeat, that it is by a change amongſt the principles, and by a particular combination between the hidrogen, the carbon, and the oxigen, that this production of the empyreumatic acids takes place.

2. It is more eſſential to remark that theſe acids, though different from each other, have, neverthele ſs, ſome generic characters by which they approximate to each other. They derive theſe characteriſtic properties from the very nature of the phenomenon which has given riſe to them; they have all a burned taſte, a particular fetid acrimony, which chemiſts long termed *Empyreuma*. It is manifeſtly the ſame as that which

diſtinguiſhes the oils produced by diſtillation, which are alſo deſignated by the expreſſion of empyreumatic oils. We alſo ſee that the ſubſtances that afford theſe acids are at the ſame time ſuſceptible of yielding empyreumatic oil, and that the ſubſtances which yield no oil do not furniſh acids. It is in this manner that the citric acid, and eſpecially the oxalic acid, which preſent no trace of oil in their diſtillation, likewiſe preſent none of acid, whilſt the tartarous acid, from which a very ſenſible quantity of oil is extracted, yields at the ſame time pyrotartarous acid.

3. Hitherto only three empyreumatic acids are known; though it is very probable that ſeveral others will be found by examining well the products of a greater number of vegetables than has hitherto been done, eſpecially when we reflect that chemiſts, whoſe attention has long been engaged by the property which vegetable ſubſtances poſſeſs of affording acid liquors by diſtillation, have thought it one of the characters the moſt proper for diſtinguiſhing theſe matters from the animal ſubſtances.

The three ſpecies of empyreumatic acids hitherto known, are the *pyromucous*, the *pyrotartarous*, and the *pyroligneous.*[*]

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[*] Though theſe acids are now known to be the acetous ſlightly altered by oil, I have not thought fit to omit the ſubſequent ſpecies. See appendix.

SPECIES I.

Pyromucous Acid.

1. I HAVE already deſcribed this acid in the hiſtory of the mucous bodies and ſugar to which it belongs, as a conſtant product of the action which fire exerts upon them. I ſhall here repeat nothing concerning its properties, except what may ſerve to characterize it, by comparing it with the two others, and what belongs to its formation. Both theſe conſiderations muſt conduct us to a better knowledge of the nature of its products, and the characters by which they approach to, or are removed from the other genera of theſe compounds.

2. As to the origin, or the formation of the pyromucous acid, by collecting under the ſame genus the different immediate materials of vegetables which afford this ſpecies of acid by diſtillation, or the action of fire in general, gum, the mucilages, the ſaccharine ſubſtances, and the amilaceous fecula, we ſee that they have four very diſtinct and very remarkable properties: the firſt, that they are ſweet, taſteleſs or inſipid; the ſecond, that they form, with hot or cold water, gelatinous bodies; the third, that they contain and yield much coal in their analyſis; the fourth, that they are all converted into malic and oxalic acids, and ſome of them at firſt into mucous or ſachlactic acid. It is

very evident, that theſe four properties agree well with that of affording pyromucous acid, that they depend upon the ſame cauſe, upon the ſame primitive compoſition, upon a very near relation between the proportions of their elements.

3. The pyromucous acid is characterized by its reddiſh or brown colour, its pungent taſte, which, though empyreumatic in general, is different from that of the two other acid products of fire, its ſmell equally diſtinct and particular, its property of ſtaining the ſkin red; the ſalts which it forms with the different baſes, its attractions for thoſe baſes, and the coaly mark which it always leaves upon the veſſels in which it is heated. It cannot be doubted that it conſiſts of carbon and hidrogen combined with oxigen, though the proportions of theſe principles are yet unknown. It is known that by its laſt decompoſition it yields water, carbonic acid, and inſulated coal.

SPECIES II.

Pyrotartarous Acid.

1. THE tartarous acidule, and the acid which is extracted from it, afford, as I have already mentioned, a particular acid by diſtillation, and this acid has no more analogy with that from which it proceeds, than is found between the pyromu-

cous acid and the ſubſtances which furniſh it. I have indicated the characters of this empyreumatic acid; we have ſeen that its ſmell, its taſte, and eſpecially the ſalts which it forms with the earthy, alkaline, and metallic baſes, diſtinguiſh it from all others, and have induced chemiſts, at all times, to acknowledge it as a particular product.

2. What is very remarkable in the production of this pyrotartarous acid, is that it is furniſhed only by the tartarous acid, and by the compounds into which it enters. The cauſe of this phenomenon, by which the pyrotartarous acid alſo differs greatly from the pyromucous, will be found when the analyſis of theſe two acids ſhall be made, and the proportion of the principles that enter into their compoſition determined.

SPECIES III.

Pyroligneous Acid.

1. THE pyroligneous acid reſembles the pyrotartarous acid in the circumſtance that there is only one particular vegetable ſubſtance that furniſhes it by the action of the fire: this is the ligneous matter, or wood, as its name expreſſes. I ſhall not treat farther concerning this acid in this place, as its hiſtory ought to be placed under that of the ligneous matter to which it belongs. I ſhall only obſerve, that the pyroligneous

ligneous acid, afforded by all diſtilled woods, is well characterized by its particular ſmell, its colouring property, and the ſalts which it forms with the earths and alkalis. The difference of this acid, from the two preceding, depends upon the primitive nature of the ligneous ſubſtance, which is very different from that of the mucilages and the tartarous acid.

SECTION V.

Of the Fourth Genus of Vegetable Acids; or of the Factitious Acids, which have not hitherto been found in Nature.

1. IN the ingenious method of treating the vegetable ſubſtances by the powerful acids, and eſpecially by the nitric acid, diſcovered in 1776, by the illuſtrious Bergman, theſe ſubſtances are converted into ſeveral acids, which did not previouſly exiſt, and I have ſhown that this converſion is owing to the change of the proportion of the principles, occaſioned by the oxigen of the acid, which ſeizes the vegetable ſubſtance. In this mode of action, which is explained by the pneumatic doctrine, there are two kinds of acid formed; the one are entirely ſimilar to the acids found in the vegetables; the others, on the contrary, are altogether different from thoſe which are found in the different vegetable

getable ſubſtances, or at leaſt from thoſe that have hitherto been found, for we muſt not confound the limits of art with thoſe of nature. Theſe form the fourth genus which I diſtinguiſh.

2. It is not difficult to conceive, from what I have hitherto ſhown, that they derive their origin from a matter, or from ſome matters originally different from thoſe which afford the following; and in fact one of them, though it may proceed from ſeveral analogous matters, has however, in ſome meaſure, a ſtrict limit of formation; this is the mucous or ſachlactic acid; the two others are produced ſeverally by one of the particular matters, which are termed immediate materials of vegetables; the one with camphor, which on that account is termed camphoric acid; the other with the cork or the epidermis of the barks, which I term in general *ſuber;* and on account of this origin the acid is termed the *ſuberic acid.*

SPECIES I.

Mucous Acid.

1. I HAVE already given, in the hiſtory of gum, an account of the properties of the mucous, or ſachlactic acid: without returning

again to what I have ſaid concerning it, I content myſelf with repeating that the inſipid mucilages are the only ſubſtances that furniſh this acid, which was firſt diſcovered by Scheele, and which he for ſome time thought to be peculiar to the ſugar of milk; that the ſaccharine matter does not furniſh it by the action of the nitric acid, and that it is diſtinguiſhed from all the other artificial acids by its pulverulent ſtate, its little ſolubility, its weak taſte, and by its ſaline compounds.

2. The exact proportion of its principles has not yet been aſcertained, nor is it known how far it differs in this reſpect from all the other vegetable acids. It may be ſuppoſed to contain a very large proportion of carbon, and that to the ſuperabundance of this principle are to be aſcribed its dry ſtate, its inſipidity, its inſolubility, its inalterability, and all the other properties by which it is characterized.

It is, therefore, an acid hitherto too little known, and which deſerves to be examined with great care, eſpecially in its compariſon with the other ſpecies of acids with binary radicals, with hidrogenated carbon, or carbonated hidrogen.

SPECIES II.

Camphoric Acid.

1. THIS is never formed except at the expenſe of camphor; I refer its hiſtory to that of this ſubſtance; I ſhall here only obſerve, that being produced by a ſtrong and long continued action of nitric acid, it enjoys properties well characterized as a peculiar acid; that it approaches in its nature to the benzoic acid, with which it has even been confounded by ſeveral modern chemiſts; but that it would differ from it, had it no other diſtinctive property than that of not being ſeparated from its ſolution in alcohol by water, whilſt the benzoic acid is very eaſily ſeparated in this manner. Beſides which I ſhall hereafter ſhow it to poſſeſs many other characteriſtic properties.

SPECIES III.

Suberic Acid.

1. THE ſame is the caſe with the ſuberic acid, the conſtant production of the action of the nitric acid upon cork: when once formed, it

enjoys properties which diſtinguiſh it from all other artificial acids. Its ſmell, its decompoſition by fire, its manner of ſeparating from a fatty ſubſtance at the moment when it is formed, are characters well pronounced, and well diſtinctive of its ſpecies, not to mention other individul properties belonging to it, of which I ſhall treat hereafter.

SECTION VI.

Of the Fifth Genus of Vegetable Acids; or of the Artificial Acids reſembling thoſe of Nature.

1. I CANNOT dwell too much upon, or revert too often to the important diſcovery of artificial acidification, and the approximation which exiſts, if not between the proceſſes, at leaſt between the reſults of the efforts of art, and of the operations of nature. It is extremely ſtriking in the converſion of the not acid vegetable matters into acid ſubſtances, perfectly ſimilar to thoſe created by vegetation. This identity proves that the change that has taken place in theſe matters, at the time of their artificial tranſition into the ſtate of acids, is the ſame as that which they experience in nature.

2. Three vegetable acids formed by the efforts of art have been diſcovered: beſides the oxalic acid, which was at firſt termed acid of ſugar, and found perfectly analogous to that of ſorrel, &c. the malic and the tartarous acids have been enumerated in this order. I ſhall here ſay a few words concerning each of theſe factitious acids, of which I have already ſpoken, or which I have deſcribed as native acids.

SPECIES I.

Factitious Malic Acid.

1. SCHEELE was the firſt who aſſerted that he had converted the inſipid, or not acid vegetable ſubſtances into malic acid. He even found that all thoſe that yielded oxalic acid by the nitric acid, were at the ſame time capable of furniſhing malic acid. Mr. Hermſtaedt has ſince conſidered the factitious malic acid as a kind of preliminary to the oxalic acid, as on the one hand it is produced at the ſame time with it, and on the other capable of paſſing to the ſtate of oxalic acid.

2. Since the time of Scheele, it has been diſcovered that the oxigenated muriatic acid poſſeſſes the property of converting the inſipid vegetable ſubſtances into malic acid much

more ſpeedily than is done by the nitric acid, that this converſion is more permanent, that it paſſes leſs eaſily into the ſtate of oxalic acid, than when it is produced by the action of the nitric acid. It is ſufficient to throw gum in the ſtate of powder into the liquid oxigenated muriatic acid, and to ſtir it therein for ſome time, in order to convert it into malic acid.

SPECIES II.

1. THE opinion of the poſſibility of forming the tartarous acid artificially, reſts upon the authority of Meſſrs. Crell and Hermſtaedt. They have aſſerted that they have ſucceeded in effecting this decompoſition by means of the nitric acid; but no chemiſt has ſpoken of it ſince, or confirmed their firſt reſult. The poſſibility of the circumſtance, however, cannot be denied, unleſs we have exact experiments to oppoſe to their aſſertion; and there is nothing to oppoſe the poſſibility of this acid being formed by the efforts of art, as ſeveral others are formed.

Species III.

Factitious Oxalic Acid.

1. OF all the acids that exiſt in nature, this is the moſt eaſily and moſt abundantly imitated or fabricated by art. Beſides the mucus and the ſugar, whoſe converſion into this acid by means of the nitric acid I have already indicated, we ſhall ſee hereafter, that a great number of vegetable and animal ſubſtances equally poſſeſs the property of furniſhing it by the action of the ſame acid. I have already fully examined its properties, I ſhall here only add its moſt diſtinctive characters founded upon its cryſtallizability, its rapid decompoſition into water and carbonic acid, its attraction for lime ſuperior to that of all the other acids, and the inſoluble ſalt which it forms with this baſe, whether it be combined with it in an immediate manner, or whether it takes it away from any other acid.

SECTION VII.

Of the Sixth Genus of Vegetable Acids; or of the Acids produced by Fermentation.

1. NOTHING is more common than to ſee vegetable matters become ſpontaneouſly acid, by a proper inteſtine motion of their own ſubſtance. Beſides the amylaceous fecula, the vinous liquors, &c. the ſtalks, the leaves macerated in water, ſpeedily aſſume the acid nature; and the roots undergo the ſame alteration. Theſe are real fermented acids that are formed under theſe circumſtances, and there has even been deduced from their formation a well-marked character of the vegetable ſubſtances, by calling them *aceſcent*.

2. Notwithſtanding the multiplicity of vegetable ſubſtances that become acid by fermentation; notwithſtanding the very natural preſumption which leads us to believe that ſeveral different acids are formed by this inteſtine motion, only two acids have yet been diſtinguiſhed amongſt theſe products. And one of the two, the acetic acid, is merely a modification of the acetous.

SPECIES I.

Acetous Acid.

1. AS the properties of this acid will be explained in detail in the article concerning the acid fermentation, I ſhall content myſelf in this place with obſerving that this acid is not conſtantly the product of fermentation; that it is not always the effect of the ſourneſs of wine; but that it frequently proceeds from the alteration produced in vegetable ſubſtances by the ſulphuric or muriatic acid.

SPECIES II.

Acetic Acid.

1. THOUGH the acetic acid, the hiſtory of which will follow that of the preceding, is ranked here as a product of fermentation, it is merely a conſequence of acidification, and it ſucceeds the formation of the acetous acid; from which, as ſhall be ſhown hereafter, it differs only by a particular modification.

ARTICLE VIII.

Of the Fifth of the immediate Materials of Vegetables: of the Fecula.

A. *Situation.*

1. THE name of fecula is applied in chemiſtry to the dry, pulverulent and eſpecially white matter, which is precipitated from water in which ſeveral parenchymas of vegetables have been ſteeped. Though this name has alſo been given to the fibrous ſubſtances which impair the tranſparency of the expreſſed juices of plants, after the Latin word *fæx fæces (ordure)*, and though it is in conformity with this expreſſion that the juices are ſaid to be *defecated*, in order to deprive them in fact of their fecula, yet theſe remains of vegetable fibres, which belong to the ligneous matter, are at preſent no longer confounded with the fecula properly ſo called. On this account it has been propoſed to deſignate this by the expreſſion of *amylaceous fecula*, becauſe ſtarch is in fact the firſt and the moſt known of theſe ſubſtances.

2. The fecula properly ſo called, or the amylaceous fecula, is met with in different organs of vegetables; it exiſts in all the tuberous roots, ſuch as thoſe of the potatoe, of the orchis, of briony,

briony of manioc, &c. It is evident that the claſs of theſe feculent roots muſt be extremely numerous and varied, and that in general we may recognize them by their brittle, ſeemingly granulated parenchyma, eaſy to be bruiſed, and reduced into a ſoft paſte under the finger, and preſenting in this paſte, when expoſed to a ſtrong light or to the rays of the ſun, a brilliant, ſilky, or ſilver-like texture. We may alſo convince ourſelves of the exiſtence of the fecula in roots, by the property which they have, when they have been bruiſed, of giving to water in which they are agitated a milky opacity, as I ſhall ſoon ſhow more fully. Laſtly, theſe roots, more or leſs charged with fecula, are alſo characterized by the property of becoming brittle, and more or leſs tranſparent, when they are dried, either by expoſure to the rays of the ſun, or by the heat of a moderately warmed ſtove.

3. There are ſome ſtalks of plants, or rather trunks of trees, which contain a more or leſs conſiderable quantity of fecula, ſuch is eſpecially the trunk of the palm tree, and undoubtedly of a much greater number of trees or plants which are not yet known, and which furniſh in ſome climates an abundant nutriment to men and animals. There are as yet only ſome ſpecies of the palm, and eſpecially the trunk of the *cycas circinnalis*, from which the nations of Aſia known by the European travellers and

philoſophers derive a conſiderable quantity of fecula, as I ſhall ſhow hereafter.

4. In the enumeration of the vegetable parts which afford fecula, I muſt not omit obſerving that none of it is extracted either from the leaves or the flowers, and that what is ſometimes termed fecula, and is ſeparated from the juice of the firſt of theſe organs, is only a detached portion of the fibrous texture or of the ligneous ſubſtance which impaired its tranſparency; accordingly, as I have already indicated, this fibrous fecula ought not to be confounded with the real amylaceous fecula; and nothing is more proper for well fixing their difference than the propoſition that neither the leaves properly ſo called, nor the flowers, contain any of the latter.

5. Some fruits, and eſpecially all thoſe that are fleſhy, parenchymatous, brittle, ſuſceptible of being dried or baked, and ſoftened by hot water into a kind of ſemi-tranſparent jelly, contain a more or leſs conſiderable quantity of real fecula, though chemiſts have hitherto ſcarcely remarked it, becauſe they knew that it is not extracted from them, and that it cannot be prepared and employed like the other fecula. And in fact, theſe fruits are at the ſame time more or leſs pulpy, ſaccharine, mucous, and mixed with ſo large a quantity of inſipid or ſaccharine mucilage, with which the fecula intimately adheres, that it would be difficult to extract it from theſe mixtures for economical

uſes: but it is, nevertheleſs true, that when theſe ſoluble and viſcous ſubſtances have been extracted by chemical operations, by accurate preſſure and waſhing, there remains a white matter, in a brittle paſte, ſtill mixed with fibrous and ligneous matter, but which contains amylaceous fecula, more harſh and crude indeed than that which is furniſhed by the other parts of plants.

6. The ſeeds or the grains ſeem to be the vegetable organs in which nature has depoſited the largeſt quantity of amylaceous fecula; and as it is in theſe ſubſtances that animals find the moſt abundant nutriment, we alſo find by obſervation that this matter is deſtined by nature to ſerve as aliment to the vegetable embryo. There are even ſome ſeeds, eſpecially thoſe of the gramineous plants, which ſeem to be entirely formed of this feculent matter: accordingly, it is from this kind of parts that the moſt pure and the moſt abundant ſtarch is extracted. In many other grains the amylaceous fecula is mixed with colouring parts, extracts, mucilage, or oil. In this conſiſts the chemical difference which exiſts between the different kinds of ſeeds.

7. Laſtly, there are ſome ſpecies of vegetables, the whole of which and all their parts appear to be tiſſues of feculent matter, or to contain ſuch an abundance of it that they ſerve entirely to form real farina. Such the genus of lichen appears eſpecially to be, amongſt the

ſpecies of which are particularly diſtinguiſhed the *Lichen Iſlandicus*, of which a kind of bread is formed in Iceland, and the *lichen rangiferinus*, which ſo eaſily nouriſhes the rein-deer. Such appear to be alſo ſeveral ſpecies of ferns, the ſtalk or the roots of which furniſh the inhabitants of ſeveral of the South-Sea iſlands with a food which much reſembles our farinaceous aliments, and is converted, by baking, into a kind of cake or agreeable paſte, ſimilar to our bread prepared from grain.

B. *Extraction.*

8. The amylaceous fecula is extracted by ſimply pounding the vegetable parts that contain it, and agitating theſe pounded parts in water. The fecula is often found to be mixed with two kinds of ſubſtances: the one ſoluble in water, which remains diſſolved in the ſupernatant liquor; and the others, not being ſoluble in this liquid, are parenchymatous, fibrous and woody. The latter, which are much heavier and much groſſer than the fecula, are firſt depoſited in flakes, and leave the ſtarch ſuſpended, in a very fine and very light white powder in the water, which is then turbid like milk.

9. In order to ſeparate this parenchymatous, groſs and heavy matter from the pulverulent fecula, which is capable of being ſuſpended for a very conſiderable time in water, a very ſimple and commodious means is employed. After

having raſped the feculent root, the flaky pulp which proceeds from it is put upon a rather cloſe hair-ſieve; water is poured upon this pulp, which is worked with the hand, and rubbed with a rounded ſpatula. The water, interpoſing itſelf between the particles of this parenchymatous pulp, and being every where in contact with it, detaches from it the fecula with which it is enveloped, and carries it along with it through the meſhes of the ſieve. This waſhing and agitation is continued till the water runs off without opacity, that is to ſay, till it has carried away all the fecula: there then remains upon the filtre a parenchymatous grey or ſemi-tranſparent portion. The water which paſſes through the ſieve falls into the veſſel, in which it is received turbid and white like milk; it depoſits in the courſe of time all the fecula which it contains, in a white layer which occupies the lower part of the veſſel, and diminiſhes in thickneſs in proportion as its particles approach each other, but remains thick and like a very fine paſte, on account of the water which it retains between its particles. The water that has become clear at its ſurface is poured off; the fecula is dried after it has been cut into fragments, which are ſpread upon pieces of blotting paper; when it is ſufficiently dry to be eaſily divided by the preſſure of the finger into a fine and ſoft powder, it is properly prepared.

10. This operation is moſt frequently performed in the large way for the purpoſes of life,

and then it is practiſed in raſping mills moved by handſes, or even by water: in this manner the potatoe is treated. As to the farinaceous grains which are almoſt entirely compoſed of amylaceous fecula, it is almoſt always thought ſufficient to bruiſe them under mill-ſtones moved by the wind, water, or fire-engines. This ground corn yields the farina, and is ſeparated more or leſs eaſily from the bran or the ſkins bruiſed by the mill-ſtone, according to the kind of grain which is employed. However this farina is not conſidered as pure fecula; it is neceſſary to waſh it with water, and ſuffer it to depoſit the ſtarch which this fluid dilutes and carries with it, in order to ſeparate it from the portion of ſoluble and inſoluble matters which it contains, and of which I ſhall ſpeak hereafter.

11. It is eaſy to ſee, that according to the greater or leſs purity of the fecula, or according to its natural mixture with different ſubſtances, ſuch as the mucilages, the ſaccharine bodies, the extracts or the colouring parts which it contains, it requires to be treated by a more or leſs careful or repeated waſhing; the water diſſolves theſe foreign ſubſtances and thus retains them, ſuffering the fecula to be precipitated. By evaporating the liquid, by means of fire, we collect theſe ſoluble ſubſtances, diſcover their nature, and determine their quantity. In the proceſs of the purification of the fecula, the waſhing is continued

till the water employed has neither colour nor ſmell. There is no feculent vegetable matter, however acrid, however bitter, however coloured it may be, which will not by this means yield pure and white fecula. In this manner ſtarch is extracted in conſiderable purity from all the farinas of leguminous ſeeds, yellow, green, or fawn-coloured, and even from the acorn and the horſe-cheſtnut, which however are of all the ſeeds thoſe which contain the moſt matter foreign to this vegetable principle, and of an acrid, acerb, bitter, or diſagreeable taſte. There are a great number of ſubſtances which, if treated in this manner, might become uſeful, but which have not hitherto been employed for this purpoſe.

12. When the fecula is accompanied with oily ſubſtance, which is eſpecially the caſe in the grains of the cruciferous plants, in the ſeeds of the ſyngeneſian compounds or plants, in the kernels of ſtone-fruit, in the ſeeds of the cucurbitaceous plants, &c. we begin, in order to extract it, with the expreſſion of the oil, as ſhall be ſhown in the hiſtory of this laſt ſubſtance. When the oil has been ſeparated, the paſte or the cake which comes out of the preſs is waſhed with water, as the pulps of the roots the ſtalks, the farinæ of the gramineous plants are treated; and in fact, when once exhauſted of oil, the parenchyma of the ſeeds, which are in general called *emulſive*, ſuffers its fecula to precipitate from the water; whereas, previous

to the extraction of the oily ſubſtance, it remains ſuſpended with the oil in the ſtate of emulſion; however there is a part which is attached to the parenchymatous portion of theſe ſeeds that does not enter into the emulſive liquor.

13. The advantageous effects of the employment of water in the ſeparation and purification of the fecula will be ſtill better conceived, when it is remarked, that we may thus even obtain it pure, wholeſome, mild, and alimentary, from the midſt of the moſt acrid and poiſonous pulps, without its retaining any thing of the deleterious property of the pernicious juice, or extract which accompanies it. In the diſtinction of the ſpecies I ſhall eſpecially apply this remark to the fecula of briony, that of the manioc, &c.

C. *Phyſical Properties.*

14. The fecula thus extracted, prepared and purified, is a white powder of a faint taſte, or almoſt without any, very little or very ſlightly paſty in the mouth, more or leſs adheſive to the tongue and palate, light and ſoft under the finger, dividing itſelf very eaſily, attaching itſelf ſenſibly to the ſkin, to which it adheres when applied to it rather ſtrongly.

15. When viewed with attention, eſpecially while the rays of the ſun fall upon it, or with a good magnifying glaſs, we perceive

it to be formed of ſmall tranſparent globules, brilliant, ſilvery, ſilky in their maſs, and reſembling a kind of cryſtalline matter: when compreſſed with force, it emits a ſlight ſound, a peculiar kind of crackling, which every one muſt have obſerved in fine and well prepared powder.

16. It floats upon water, appearing at firſt not to become moiſtened, and is penetrated by that liquid but very ſlowly; it even poſſeſſes when thrown upon this liquid, a kind of oſcillatory or rotatory motion, which continues a long time, and does not ceaſe till oil is applied to the ſurface of the water, or till it is entirely impregnated with this liquid.

D. *Chemical Properties.*

17. It muſt firſt be obſerved, in order to underſtand the chemical properties of pure fecula, that, from whatever vegetable matters it is extracted, whatever coloured or ſapid admixture it had at firſt, it is always the ſame with reſpect to its intimate nature, and that it is an abſolutely identical body, to whatſoever plant it may have belonged. It preſents only ſome differences of whiteneſs, fineneſs, apparent texture, or lightneſs; but its intimate qualities or its nature preſent none.

18. Well purified ſtarch, which I ſhall take as an example of the genus, when expoſed to the fire and air, upon an ignited coal, becomes coloured,

paſſes through the ſhades of yellow, orange, red, and brown, before it becomes black; is ſoftened, ſwells, exhales a pungent white fume, of a not diſagreeable acid ſmell, analogous to that of mucus and of ſugar. The coal which is thus formed is a little more voluminous than the ſubſtance itſelf was, though ſenſibly leſs ſo than that of gum. When diſtilled with a pneumato-chemical apparatus, water is obtained charged with pyromucous acid, ſome drops of red or brown oil, much carbonic acid, and carbonated hidrogen gas. This laſt burns with a light blue flame, and in a rapid manner; its flame, when it is kindled in a narrow and long bell-glaſs, deſcends horizontally in the veſſel; there remains a coal of a ſingle piece, a little ſpongy, eaſy to be burned, which leaves only ſome traces of pot-aſh and of lime; the latter is united with phoſphoric acid. This analyſis reſembles that of the mucus.

19. Starch does not appear to experience any conſiderable alteration by expoſure to the air; through it attracts moiſture; it collapſes and becomes in the courſe of time fatty and viſcous, as it were, and contracts a ſour taſte, with a ſmell as if rancid; but it requires a great length of time before this effect is produced. There is no mutual action between ſtarch and the ſimple combuſtible bodies.

20. It may be diluted in pure and cold water, by motion and agitation; and forms with it a kind of paſte without coheſion, and not ductile,

which dries and cracks in the air. When a larger quantity of liquid is added, the ſtarch remains for ſome time ſuſpended in it, and appears like a kind of thick milk. If we ſuffer it to remain in this ſtate with the water at a temperature that exceeds fifteen degrees of Reaumer, it ferments, riſes, becomes a little heated, and turns ſour. Theſe phenomena take place in a much more ſpeedy and powerful manner, when it contains ſome foreign principles, ſuch as the gluten, or an extractive and colouring matter: thus the farina of corn ferments, and becomes ſpontaneouſly ſour in the proceſs of ſtarch-making; but in this work itſelf, the portion of ſtarch which eſcapes aceſceney, is ſeparated more pure and white from the different foreign matters that were united with it. It is believed that the acid which is formed in this caſe, and which exiſts in ſo marked a manner in the ſour water of the ſtarch-makers, is acetous acid; though I do not know that it has been ſubmitted to a particular examination.

21. Boiling water acts upon ſtarch in a very different manner. At this temperature, the whole of the fecula is diſſolved in the liquid; it forms a kind of gelatinous tranſparent ſubſtance. On this account the product of this operation is termed potatoe-jelly, when it is made with the fecula extracted from that root. This property is the diſtinctive character of pure fecula. There is no fecula, from whatever vegetable matter it may have been taken, which

does not preſent it in a more or leſs marked manner, and which is not eaſily recognizable by the gelatinous and tranſparent conſiſtence which it aſſumes by this operation. It then becomes very ſimilar to a mucilage, and appears to paſs into the mucous ſtate. In fact, if we expoſe to a gentle and ſufficiently continued heat, this ſpecies of vegetable jelly, it thickens, dries, becomes brittle, retaining a ſemi-tranſparency, and greatly reſembles a gum, all the products of which it affords. In this ſtate it is very difficult to diſtinguiſh it from the mucous ſubſtance, and it deviates from it only by very ſlight differences: accordingly, moſt chemiſts have been led to conſider the fecula as a kind of mucilage condenſed, become dry and pulverulent, and inſoluble in cold water, by the progreſs of vegetation itſelf, ſuſceptible of repaſsing into its former ſtate by the combined action of caloric and of water. This opinion becomes very probable when we obſerve that the vegetable ſubſtances moſt ſuſceptible of becoming charged or filled with ſtarch, preſent, previous to its formation, a kind of tranſparent jelly, which becomes white like milk, afterwards thickens, condenſes, and dries in proportion as its maturity advances. The accuracy of this obſervation is known in all the cereal grains, and in the emulſive ſeeds, which paſs through the ſucceſſive ſtates of jelly, of thick milk, and of a kind of mucilage, tranſparent, and afterwards opaque, before they aſſume the ſolidity which ought to characterize them.

22. In this gelatinous or mucous ſtate, which the fecula aſſumes by means of boiling water, it has the faint taſte or inſipidity of the mucilages, the property of being thickened by the action of the fire, or being diluted and diſſolved in water, and of turning ſour in the courſe of time. It particularly acquires the property of being eaſily digeſted, and ſerving for the nouriſhment of man, with much greater promptitude than it could in its dry, pulverulent, and inſoluble form. Accordingly this kind of boiling or ſolution in hot water, which is manifeſted and marked by a particular ſmell which is ſufficiently agreeable, is the moſt general, and, in ſome meaſure, the moſt conſtant preparation which men employ for converting the fecula into a more pleaſant and lighter nutriment, which very quickly recruits their ſtrength, and is ſpeedily converted into their own ſubſtance. It is eſpecially under this form that it is given to children, with whom it is ſometimes ſubſtituted inſtead of the milk of their mothers, or ſupplies its place pretty conſtantly, as we ſee amongſt moſt civilized nations.

23. The acids with ſimple radicals, alter the amylaceous fecula more or leſs powerfully, and comport themſelves with it preciſely in the ſame manner as with mucus. When diluted with water they diſſolve it, eſpecially with the aid of heat, much more quickly and eaſily than water

alone does; they form with it a kind of jelly or mucilage of a perfect tranſparency: when they are concentrated they decompoſe it. The ſulphuric acid blackens it, forms water and acetous acid by the union of its principles, which it ſolicits in another order than that in which they were combined, and precipitates carbon from it. With the aſſiſtance of fire it diſengages carbonated hidrogen gas from it, as it does from gum or ſugar. The muriatic acid acts in the ſame manner upon ſtarch, but much more ſlowly than the preceding acid. The nitric acid diſſolves it by heat without reducing it to coal, diſengages nitrous and carbonic acid gas, does not precipitate mucous acid from it, as it does from the gums, but converts the whole amylaceous maſs into malic and oxalic acids. The carbonic acid renders the fecula more ſoluble, and promotes its aceſcency.

24. The cauſtic or pure alkalis, diſſolve fecula with the help of water, reduce it to a gelatinous ſtate, but do not alter its intimate nature except with difficulty and at a high temperature. The ſalts which quickly part with oxigen, burn and decompoſe it. Thus it is deſtroyed by nitrate of pot-aſh when heated with it. It inflames and detonates violently by mere preſſure or percuſſion, with the ſuper-oxigenated muriate of pot-aſh, which inflames it.

25. The metallic oxides alſo burn it, eſpecially thoſe that are little tenacious of their oxigen; the ſame is the caſe with the metallic

ſolutions, from which it frequently ſeparates the oxides by mere contact, continued for a longer or ſhorter ſpace of time, colouring them, as they uſually are, according to the different proportions of oxigen which they yield to it.

26. Fecula unites eaſily in nature, and even by the operations of art, with moſt of the different immediate materials of vegetables; thus it is found aſſociated in plants with the extracts, the mucus, the ſugar, the oils, the colouring matters, and the gluten. Art alſo effects theſe factitious aſſociations pretty eaſily, eſpecially that with the colouring ſubſtances; by this means, as I ſhall ſhow elſewhere, are fabricated the colours ſo much uſed for paper, and ſometimes even for valuable paintings, which are known by the name of lakes.

27. From all the chemical properties which I have juſt preſented relative to the amylaceous fecula, it may be concluded that this body is a kind of dry and pulverulent mucus, different however from the gummy matter in its affording no mucus acid by the action of the nitric acid, and its not being ſoluble in cold, but only in boiling water. It announces itſelf as being a little leſs carbonated than the latter, though I cannot yet preſent the proportion of the principles that enter into its compoſition. It might be ſaid to follow the ſaccharine matter very nearly, and we ſhall ſee hereafter that it appears to be actually capable of forming it by a peculiar alteration of its own ſubſtance. As ſome chemiſts have announced that the fecula

affords ſenſible traces of ammonia in its analyſis, it ſhould ſeem, from this circumſtance, that the fecula contains azote amongſt its primitive principles. However this aſſertion relative to the production of ammonia in the analyſis of ſtarch by fire wants confirmation, and cannot yet be admitted as a demonſtrated fact.

E. *Species of Feculas.*

28. Though there is only a ſingle ſubſtance that ought to bear the name of fecula or ſtarch; though this ſubſtance is exactly of the ſame nature in all vegetables, when it has been extracted and purified with eaſe by chemical proceſſes, it is a matter of too great importance to ſociety to be well acquainted with the principal ſtates in which it exiſts in nature, as is alſo the art, which is founded upon this knowledge, of applying it to the different uſes to which it may be made ſubſervient, for us to omit paying ſome attention to the ſpecies of it which nature preſents. It is very evident at firſt that the diſtinction of theſe ſpecies can be founded, and their real difference eſtabliſhed, only upon the different mixtures which it preſents in the vegetables that furniſh it, as well as upon the diverſity itſelf of the parts from which it is extracted.

29. Under the firſt relation, that is to ſay, under that of the different mixtures, or combinations which diſtinguiſh the amylaceous fecula in vegetables that contain it, we may

admit ſix principal ſtates, or ſix ſpecies of fecula, according to the nature of theſe different ſubſtances which are mixed with it. I ſhall firſt obſerve, that it is no where abſolutely or intirely pure and inſulated, that wherever it is met with, it is alloyed with ſome foreign ſubſtances, and that on this account we are obliged to ſeparate it by water, which takes it up in powder and depoſits it, retaining the ſoluble matters, and leaving ſeparate the groſs parenchymas which likewiſe altered it. The ſix principal ſpecies which I diſtinguiſh, by adding to their names adjectives which characterize each foreign matter, are the *glutinous fecula*, the *extractive fecula*, the *mucous fecula*, the *ſaccharine fecula*, the *oily fecula*, and the *acrid fecula.*

A. The *glutinous* fecula is that which is found naturally united with glutinous matter; it is found in wheat, and, in general, in all the cereal grains, though moſt of them contain much leſs gluten than the firſt. We ſhall ſee in the ſubſequent article by what proceſs the ſeparation of the gluten, which gives it particular properties, is effected.

B. The *extractive* fecula always recognizable by its fawn, yellow, greeniſh, &c. colour, is eſpecially found in the leguminous ſeeds, and in the farina which is obtained from them by grinding. It is to an extract that it owes its colour and its harſh, acerb, herbaceous, bitter taſte, as well as its more or leſs pungent ſmell. The farina of peas, lentiles, French beans, lupines;

pines, chich-peas, &c. is of this ſpecies. There are alſo found varieties more inſupportable and more difficult to be purified in the horſe-cheſtnut, the acorn, &c. It is very difficult to extract it pure, which requires long and abundant waſhings.

C. The *mucus* fecula, well characterized by its viſcous gluey ſtate, exiſts in many roots, in all the unripe kernels, in the cereal grains in the milky ſtate. Sometimes it is only the tranſition from the mucous to the feculent ſtate; ſometimes it remains in the gluey and mucous form at all the periods of vegetation. The root of the potatoe, *convolvulus patatas*, is the moſt marked and ſtriking example of it. This fecula is very difficult to be obtained pure.

D. The *ſaccharine* fecula, or the natural mixture of fecula and ſugar, is found in ſeveral roots, in ſome ſaps, and even in the gramineous ſeeds when they have germinated. It is one of the moſt uſeful aſſociations which nature can preſent to man, and it is the ſubſtance which he ſeeks with moſt avidity for his nouriſhment. Both food and condiment are united in this natural combination. The ſugar is very eaſy to be ſeparated from the fecula, on account of its great ſolubility in water; and the moſt ſimple waſhing is ſufficient for this operation.

E. The *oily* fecula is very frequent in a great number of emulſive ſeeds, or thoſe which by being bruiſed, together with water form a milky liquid. When the oil has been ſeparated by expreſſion,

preſſion, the fecula which remains, beſides that it obſtinately retains a ſmall quantity of it, as is perceived by the unctuoſity of the paſte of kernels, is alſo mixed or charged with a mucous and extractive matter, and even with ſome ligneous particles which cannot be ſeparated from it except by ſeveral ſucceſſive waſhings and depoſitions.

F. The *acrid* fecula, whether it be pungent, like that of the cruciferous and antiſcorbutic roots, or cauſtic and burning, like thoſe of arum, of aſſarabacca, of briony, &c. or poiſonous, like that of manioc, owes this property to a portion of the juice of the plant itſelf that remains upon its ſurface, and which, when it is dried, without having been previouſly waſhed in a large quantity of water, preſerves in it a part of the properties, whether alterative, purgative, or even poiſonous, which the intire juice itſelf poſſeſſes. We may deprive it of this taſte, and render it very mild and ſimply nutritious, by merely waſhing it with pure water, in ſufficient abundance not to leave any foreign parts.

30. It muſt be added to this enunciation of the ſix ſpecies of fecula, diſtinguiſhed by the foreign matters that are mixed or combined with it by nature, that the fecula is often found aſſociated at the ſame time with ſeveral of theſe matters, which I have only indicated ſeparately in order to preſent the mixtures in an orderly arrangement. Thus the fecula of

the leguminous plants, or the farina of peaſe, beans, &c. frequently contains one or two extracts, a colouring ſubſtance, and a mucous matter. The paſte of kernels of different kinds, beſides the oil, contains, as I have announced, colouring matter, extract, mucilage, ligneous matter, and ſometimes even ſaccharine ſubſtance. It is moreover evident, that theſe multiplied combinations may greatly vary, according to the different ſtates of modification of the trees or plants which furniſh them.

31. Another diſtinction, no leſs important to be made between the feculas, is that which relates to the vegetable parts from which they are extracted. It is to this diſtinction that the ſeries of the ſpecies of fecula which are prepared for the purpoſes of ſociety really appertains. Amongſt the feculent and acrid roots are reckoned thoſe of briony, of arum, of manioc, of potatoes, and of orchis; amongſt the ſtalks, thoſe of the palm, which furniſhes ſago; amongſt the ſeeds of the graminaceous plants, meal, properly ſo called; amongſt the claſs of vegetables which ſeem to be intirely compoſed of it, the nutritive paſte of the Lichen Iſlandicus; finally, we may alſo enumerate amongſt theſe ſpecies the paſte of paper. I muſt ſay a few words concerning each of theſe feculas in particular, and even add ſome details concerning thoſe vegetables, which, though none has hitherto been extracted from them, may afford very uſeful feculas.

A. The fecula of briony formerly was prepared for pharmaceutical uſes. After this root had been peeled, raſped, and preſſed, it was ſubmitted to the preſs, by which means a turbid and milky juice was extracted, which was filtrated; the fecula which it had precipitated upon the filtre, was waſhed, and the maſs which had remained in the preſs, was diluted with water: this laſt waſhing afforded a fecula more abundant and ſtill finer than that which was depoſited by the expreſſed juice. Theſe two feculas, mixed and waſhed for the laſt time with a ſufficient quantity of water for it to paſs off without taſte, were very pure, very taſteleſs, inſipid, or mild; no longer partaking of the acrimony of the root, they may be uſed like the ſtarch of wheat, from which they differ in no reſpect. When it was deſired to have it purgative, it was not waſhed and precipitated by means of water; but the expreſſed juice was ſuffered to form its depoſit without the addition of water. When well waſhed, on the contrary, it may be employed as food.

B. The root of the arum, that of aſſarum, and many other acrid tuberous roots of our climates, might be treated like thoſe of briony, and furniſh, like this, a white fecula, fine and pure, mild and alimentary, when well waſhed; but acrid, purgative, and emetic, in a degree the more intenſe, the larger the quantity of the juice of the plant that ſhould be left in it.

C. The root of the manioc, *jatropha manioc* of Linnæus, conſiſting of ſeveral large, fleſhy, and ovoid tubercles, is employed chiefly in America as food for man, though, like the preceding, it contains a very acrid and intenſely poiſonous juice, ſince, according to all the hiſtorians of that country, a ſpoonful is ſufficient to poiſon a man. After the freſh root has been peeled, it is incloſed in a ſack of ruſhes of a very looſe texture, which is ſuſpended to a ſtick placed upon two wooden forks; to the bottom of this ſack a heavy veſſel is ſuſpended, which, by drawing the ſack, preſſes the raſped root, and receives the juice that flows out of it. When the fecula is well exhauſted of its juice, it is expoſed to ſmoke in order to dry it, and when it is well dried it is paſſed through a ſieve. In this ſtate it is termed *caſſava*; this is a kind of farina. It is baked into cakes, by ſpreading it upon hot plates of iron or earth, and turning it upon both ſides in order to give it a gold or reddiſh colour. It is alſo formed into *couac*, or ſmall grains, reſembling ſago, by agitating it for ſeveral hours in a baſin placed over the fire. The expreſſed juice of the manioc depoſits a fecula finer than the preceding; after it has been well waſhed and dried, it is employed for making confectionary; it is termed mouſſache. We ſee here the ſame reſults as are obtained with the roots of briony, of arum, and of aſſarum.

D. The root of the *ſolanum tuberoſum*, or potatoe, has for ſeveral years paſt been employed for preparing a very fine fecula, a very fine, very white, and very mild ſtarch, which has been called *amidon de ſanté*, on account of its good properties. After theſe roots have been peeled, they are raſped, and the pulp is placed upon a cloſe hair-ſieve; water is poured upon this pulp and agitated with it, till the liquid no longer carries along with it any white matter. The liquid which paſſes off depoſits a very fine and very mild white powder, which is carefully dried, and becomes brilliant and as it were cryſtalline by this deſiccation. It preſents all the properties of pure ſtarch, which it even ſurpaſſes in fineneſs and whiteneſs, when it is well prepared. A kind of ſago is made of it, by drying it whilſt moiſt and conſtantly agitating it in a veſſel over a gentle fire. The water which ſwims above this fecula has frequently a greeniſh aſpect, which depends upon the extractive part which it has taken from the root. Raſping-mills have been contrived for preparing a large quantity of the fecula of potatoes at a time. It is alſo formed into a kind of vermicelli, by paſſing it moiſtened with a little water through a cylinder perforated with holes at its extremity, and drying the ſoft ſmall cylinders that are formed by this kind of mould.

E. Salep, which is alſo called *ſalab*, *ſalop*, &c. in different parts of the Eaſt, is formed from the roots of different ſpecies of the orchis, eſpecially the *orchis moria*, which are dried in the ſun, either after they have been boiled in water, or, which is the more frequent practice, after they have been merely cleaned and well rubbed with bruſhes in this liquid. In the latter proceſs, which is greatly preferable to the firſt, the bulbs when well bruſhed are dried in a ſtove which renders them brittle, dry and ſemi-tranſparent. The roots dried in the ſun are ſtrung in a row upon ſtrings, by means of which they are ſuſpended in the air. This ſimple preparation enables them to be eaſily reduced into powder or ground, ſo that they may afterwards be boiled in water. The ſalep thus forms a kind of very mild and very nouriſhing jelly, the analeptic and mollifying power of which was formerly much extolled. The ſame operation may be performed, and an equally wholeſome and uſeful food prepared with the more or leſs tuberous roots of all the ſpecies of orchis.

F. Sago is a dry fecula, in round and ſlightly reddiſh grains, baked or condenſed by the action of the fire, which is brought from the Moluccas, eſpecially from Java, and from the Philippine iſlands. It is extracted from a ſpecies of the palm, termed *landan* in the Moluccas, which is the *cycas circinnalis* of Linnæus. The trunk of this tree contains a white and ſweet pith, which the inhabitants extract by ſplitting the tree longitudinally. They bruiſe this pith, put it into a kind of funnel of bark, placed over a hair ſieve, and ſoak it with a large quantity of water; the

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B. The root of the arum, that of aſſarum, and many other acrid tuberous roots of our climates, might be treated like thoſe of briony, and furniſh, like this, a white fecula, fine and pure, mild and alimentary, when well waſhed; but acrid, purgative, and emetic, in a degree the more intenſe, the larger the quantity of the juice of the plant that ſhould be left in it.

C. The

all mankind as their firſt nouriſhment. Theſe properties are owing to the mixture of the three ſubſtances which conſtitute it; the amylaceous fecula properly ſo called, which forms nearly three fifths of it, and is extracted from it by waſhing the paſte, which the water carries away and depoſits in a white powder; the glutinous matter, which remains in a viſcous and elaſtic maſs after this waſhing, and of which I ſhall ſpeak in the ſubſequent article, conſtitutes nearly a fifth of the whole weight of the farina; and a ſaccharine matter which remains diſſolved in the water, and is obtained from it by evaporation. It is known that it is more eſpecially from this farina that ſtarch properly ſo called is extracted. It is alſo known that the farina of wheat muſt admit of varieties in the proportion of its three principles, according to a multitude of circumſtances of vegetation. It is alſo proper here to remark that bread which is well made, and which has fermented into leaven, is acid, that its decoction reddens the blue vegetable colours, and that it becomes ſtill more ſo in the ſtomach.

H. Several ſpecies of lichens, but eſpecially that which grows in ſuch abundance in Iceland, and which on that account is termed *Lichen Iſlandicus* by Linnæus, is employed for making a very nouriſhing kind of bread in the Northern countries. From the experiments made by the Academy of Stockholm upon this lichen, it appears that it affords by ſimple grinding an excellent ſtarch. The ſame alſo appears to be the caſe with the *lichen rangiferinus*, on which the rein-deer are ſupported, and which ſo eaſily fattens them. The inhabitants of Iceland prepare from the farina of their lichens a very delicate and much eſteemed meal. It is here to be obſerved, that ſeveral ſpecies of lichen yield, in ſome ſeaſons, a kind of ſaccharine efflorefcence upon their leaves, &c.

I. Paper itſelf is nothing more than a kind of fecula proceeding from the portion of liber ſtill mucous and ſucculent, with which the cloth had been fabricated, and which, by being torn, macerated, and boiled for a longer or ſhorter ſpace of time in water, at laſt affords a feculent mucilage, that is collected, by cooling, into a thin layer ſufficiently ſolid to oppoſe a certain reſiſtance to its being torn. This is the baſe of the facts upon which the art of paper-making is founded. This matter comports itſelf, in its chemical analyſis, abſolutely like the fecula; it affords pyromucous acid in diſtillation, and oxalic acid by the nitric acid. It is ſoluble in hot water, forms a jelly or paſte in this operation, and not to ſpeak in this place of the glue, frequently of an animal nature, with which it is covered in order to prevent it from imbibing the ink into its pores, and to render it fit for writing upon, it is evident that this ſolution of paper in boiling water might be uſed as food in caſes where preſſing neceſſity might oblige men to have recourſe to it.

F. *Uſes of the Fecula.*

32. WHAT I have hitherto obſerved with reſpect to the ſeat, the extraction, the chemical properties, and the different ſpecies of amylaceous fecula, muſt have rendered it evident that this product of vegetation, conſidered ſo improperly as a kind of earth by the ancient chemiſts, is a particular oxide, a natural compound of carbon, hidrogen and oxigen, and perhaps even of a little azote, which has eſpecially the great advantage of ſerving in an eminent degree for the nouriſhment of animals. Accordingly, all the parts of plants which contain it are the prey of numerous claſſes of theſe animated beings, from man down to the inſects, the larvae and the worms which ſeize upon them, form their abode in them, and deſtroy them more or leſs completely with the different inſtruments of manducation with which nature has provided them.

33. It is from the fecula that man derives an aliment, the moſt abundant, the moſt nouriſhing, and the moſt eaſy to be preſerved. Whilſt immenſe tribes of animals devour this ſubſtance pure, and ſuch as nature preſents it to them, man knows how to give it a thouſand

different forms, from the moſt ſimple baking or boiling, to that ſo highly perfected preparation known amongſt the inhabitants of the temperate zones by the name of *bread*; from the caſſava of the Americans to thoſe confectionaries, ſo delicate, ſo light, ſo ſweet and pleaſant to the taſte, which are made in ſome parts of Europe, eſpecially in France, in Italy, and in Germany. This primitive aliment admits of all combinations with the oils, butter, milk, cheeſe, eggs, ſugar, aromatic ſubſtances, the juices of fruits, the juices of fleſh; its natural mildneſs and inſipidity render it the appropriate recipient of a multitude of condiments.

34. Endowed with this knowledge of the eminently nouriſhing property of the amylaceous fecula, men at once enlightened and philanthropic, (for theſe two qualities are rarely divided,) may render eſſential ſervices to ſociety by greatly multiplying the ſources of alimentary matter, and ſhowing that a very numerous ſeries of vegetable ſubſtances, which are not generally employed for this purpoſe, may be very eaſily and ſucceſsfully appropriated to it. It is eſpecially in times of ſcarcity, after the unfavourable ſeaſons which too frequently deprive the people of their hopes of obtaining ſufficient proviſion for their ſubſiſtence, that all the aid which chemiſtry can afford ought to be called in to the relief of nations. A ſatisfactory idea of the important ſervices which

it is able to afford may be derived from reading ſeveral modern chemical works, eſpecially thoſe of Citizen Parmentier, who has deſerved ſo well of his country and of humanity in general, by occupying himſelf with a perſeverance which philanthropy alone could inſtigate, in the inveſtigation of all the alimentary reſources which nations may derive from the culture of the potatoe, of Turkey-wheat, or Maize, and of many other vegetable ſubſtances that have been too much neglected, notwithſtanding all the advantages which they promiſe.

35. A multitude of other ſecondary utilities accompany this firſt utility of the feculas, and render them one of the moſt valuable ſubſtances which man can derive from vegetables. Medicine has borrowed from them not only a variety of foods well appropriated to a multitude of particular circumſtances of diſeaſes, but alſo mollifying, incraſſant, agglutinating remedies, preparations adapted for allaying irritation and pain. It is ſufficiently known what advantage the art of healing derives from different farina, from the fecula of the potatoe, of ſago, of ſalep, &c. It is true that the moſt of theſe preparations have been too much extolled; and that by endeavouring to attribute to them almoſt ſupernatural and miraculous virtues, a part of the confidence which they merit has been deſtroyed. But enlightened phyſicians, equally remote from ridiculous enthuſiaſm and dange-

rous indifference, employ them with the greateſt advantage.

36. Finally, the arts perpetually employ the amylaceous fecula for a multitude of uſes or render them of important ſervice. By ebullition in water, they are made into glues, or paſtes, which ſerve to keep together a number of ſurfaces of light bodies applied the one over the other, and to effect between them an approximation and coheſion neceſſary in a multitude of circumſtances. They are alſo employed as drying ſubſtances, eſpecially for the hair: for this purpoſe what is called *hair-powder* is prepared from them; a kind of cuſtom, perhaps very ridiculous, of ſeveral modern nations, in which they imitate, without being aware of it, the nations whom they term barbarous, and by which, a circumſtance of great importance, they entirely laviſh away a very conſiderable portion of the ſubſiſtence of a great number of families: it is proper, therefore, to employ for this purpoſe ſuch feculas as are not uſed as food.

ARTICLE IX.

Of the ſixth of the immediate Materials of Vegetables; of the Gluten.

A. *Situation.*

1. THOUGH it is eſpecially in the farina of wheat that we find the glutinous ſubſtance, or the matter diſcovered by Beccari and Keſſelmeyer, and named by them *glutinous vegeto-animal* matter; though it can only be extracted from the farina of this plant, it is allowed by all chemiſts that the cereal grains contain a certain quantity of it, and that it cannot be ſeparated from them, becauſe it either exiſts in them in too little abundance, or too much diſſeminated in the amilaceous fecula or ſtarch.

2. Rouelle the younger, who had eſpecially examined and compared it with animal matters, affirms that he had found it in the coloured fecula, and eſpecially in that which was termed *the green fecula of plants.* But the expreſſion of fecula, applied indiſcriminately to the juices of the plants and to the ſtarch, having led chemiſts to conſider the latter as a part of the remains of ſolid vegetable ſubſtances, there is reaſon to believe that it was merely from analogy, and alſo from ſome equivocal properties that Rouelle imagined that the green matter contained the glutinous ſubſtance. At leaſt the experiments that have been made ſince his time, ſuch as I have ſeveral times repeated upon

theſe coloured feculas, have not afforded me the confirmation of this aſſertion, and no fact has really proved the glutinous matter to be one of the principles of this latter fecula.

3. There is a more exact and more poſitive obſervation relative to the preſence of this glutinous matter in the vegetable texture which forms linen and paper. Citizen Deſmarets has obſerved in the paper manufactories, after the heating or rotting of the rags, and when this ſubſtance is melted and ſoftened in water, that thick, ſolid, inſoluble flakes of real gluten are ſeparated. An analogous phenomenon is obſerved in the work of laundreſſes. The alkaline leys and the water charged with ſoap which they employ for waſhing linen, eſpecially finer linen, take from it a principle which ſeparates, in ſufficient abundance, in the drains into which they throw theſe liquids to choke them up, to ſtop up the grates which intercept their continuity, and to prevent theſe liquids from running. There are alſo found upon theſe grates, flakes, or maſſes almoſt ſolid, rather ſoft and ductile, manifeſtly precipitated from the leys, and ſeparated from the texture of the linen itſelf. By this means alſo this texture is gradually worn, rendered thinner and made to loſe its weight and form.

4. Laſtly, Citizen Deyeux has thought he has diſcovered the exiſtence of the glutinous ſubſtance, in the ſaps of the yoke-elm and the birch; he has even thought that this

ſubſtance is diſſolved in them by the mediation of the acetous acid, and that it was obtained precipitated from theſe liquors in inſoluble and ſolid flakes, only by the evaporation or the diſſipation of this acid. I muſt, however, obſerve, that Citizen Vauquelin, who has examined the ſame liquids, did not find them to contain the glutinous principle, but only extract. It is true that this may depend upon the difference of the ſaps which thoſe two chemiſts have examined, and that of the trees which afforded them.

5. It muſt be concluded, from what I have juſt ſet forth reſpecting the almoſt excluſive ſeat of the glutinous principle in the farina of wheat, that this ſubſtance is, perhaps, of all the immediate materials of vegetables, that which is the moſt rarely found in plants, or at leaſt that which is extracted with the moſt difficulty, which is either leſs abundant than many others, or more intimately mixed or combined with other materials, ſo that it cannot be ſeparated without the greateſt difficulty.

B. *Extraction.*

6. The glutinous principle is extracted by proceſſes ſimilar to thoſe that have already been deſcribed in ſeveral of the preceding articles, and which, being dependant upon mechanical operations, cannot change its nature or alter its compoſition. The manner in which this principle is

extracted from the farina of wheat, is one of the moſt ſimple and ingenious, and at the ſame time the moſt exact. It is by ſeparating the ſtarch from this farina that we ſeparate the glutinous principle.

7. Scarcely has a little water been thrown upon the farina, which, as I have already obſerved, alone preſents this remarkable character, when its particles approach, adhere, and ſtick to each other, forming a mild, gluey, hemogeneous paſte, eaſy to be kneaded, tenacious, elaſtic, which may be elongated, flattened, drawn in every direction, without breaking or cracking. This paſte, waſhed in a ſmall ſtream of water, and gently kneaded or worked, immediately by the hand of the operator, or well preſſed in a bag of linen, equally expoſed to a ſtream of water, ſuffers this liquid to carry away the amylaceous fecula in the form of a white powder, which renders it milky. In proportion as the water carries away this ſtarch, the paſte aſſumes a more grey colour, leſs brilliant as it were, ſemi-tranſparent, and alſo of a ſofter conſiſtence, but at the ſame time more tenacious, more viſcid, more gluey, and more elaſtic. In this manner we continue to knead the paſte of the wheat, till the water paſſes off clear, and without any feculent powder. Thus the farina is ſeparated in three ſubſtances, the ſtarch, which is precipitated in a white powder at the bottom of the water, another which remains diſſolved in the liquid, and the third which remains ſoft, coheſive, and elaſtic.

8. It is evident that this glutinous matter, which was in the ſtate of powder in the farina, aſſumes at the very inſtant in which the paſte is formed by the addition of water, the gluey and elaſtic ſtate which it did not before poſſeſs; that the ſtarch which then adheres to it but feebly, and which ſeems to have covered only the exterior fibrous faſciæ, is detached from it by mere contact of the water, and that the water contributes to its paſty and ductile ſtate. It is no leſs certain, that it is to this property of the pulverulent particles of the gluten to become elaſtic by the addition of water, that the farina of wheat owes that of forming of a paſte, and that it is in proportion to its quantity, that the panification, more or leſs ſenſible in this farina, varies according to the ſtate of maturity, the nature of the corn, and that of the ſoil, the ſeaſon, and all the circumſtances relative to the vegetation of this important plant.

9. It is very remarkable, that the gluten ſeems to diſappear, or at leaſt can no more be ſeparated or extracted from the farina of wheat; if inſtead of adding at firſt little water, and forming a thick, ductile dough, which is afterwards waſhed with a ſmall ſtream of water, we ſuddenly ſteep it in a large quantity of this liquid, and reduce it to paſte; we then, indeed, give this liquid, by means of heat, the property of forming a viſcid, thick, very gluey, and opaque maſs, as is done in the preparation of paſte; but we deprive it of that of ſeparating and inſulating the glutinous matter from the

ſtarch. It ſeems that by this dilution with a large quantity of water, we entirely inſulate the particles of this body, diſperſe them among that of the fecula, and prevent them from approaching and adhering together, as they do in the ſimple ſtate of dough. Hence it happens, that in theſe paſtes of the flour of wheat, with which wafers, vermicelli, lozenges, &c. are prepared, we can no longer, according to the experiments of Macquer and Pelletier, find again the gluten, and obtain it in the ſame manner as in the thick ductile paſtes, waſhed by means of a ſmall ſtream of water: thus the quantity of this liquid and the manner in which it is employed, has a ſingular influence upon the extraction of the gluten.

10. When the ſolid and ductile dough of the flour of wheat is left to itſelf, at a temperature of at leaſt fifteen degrees, inſtead of being waſhed with a ſmall quantity of water, in order immediately to extract the gluten from it, it quickly undergoes an inteſtine motion, which is not remarked in ſtarch equally impregnated with water; it becomes inflated and filled with cavities, produced by the diſengagement of an elaſtic fluid, and proceeds quickly towards aceſcency. This motion is accelerated by adding to the paſte a portion of a ferment taken from dough that has already riſen, or from the yeaſt of beer, as is practiſed in the fabrication of bread. If the dough be baked before it has undergone this motion, we obtain no real light bread, filled with cavities, and eaſy,

eaſy of digeſtion; but a kind of thick, heavy cake, much more difficult to be digeſted. As ſtarch alone does not preſent this phenomenon, it has been thought that the preſence of the glutinous matter was the cauſe of it. Accordingly, by adding glutinous matter artificially to a pure amylaceous fecula, which contains none of it, whether it proceed from the farina of wheat, or have been extracted from any other vegetable matter, we form a dough which riſes and affords real bread by baking. It is ſo true, that the gluten contributes to this panary fermentation, and is the real ſource of it, that well made dough ſcarcely furniſhes any more of it after having fermented, and affords none at all after the baking of the bread, though this gives out, in its analyſis by fire, a proportion of ammonia ſufficiently conſiderable to diſtinguiſh its products very well from thoſe of pure fecula.

11. It is to the ſame abſence, or at leaſt to the ſmall quantity of the glutinous matter contained in the farina of rye, of barley, of oats, and eſpecially of maize, of rice, of millet, and of all the other cereal grains, that we muſt attribute the impoſſibility of making good bread, well riſen, light and porous, with theſe farinas. Still leſs can we prepare any other than crude, heavy, inſipid cakes, with the farina, from powders of leguminous ſeeds, of the feculent roots, and of all the amylaceous vegetable powders deprived of the glutinous principle. It would be very in-

tereſting to know, whether this principle of the gluten exiſts in the farina of the lichens, with which pretty good bread is made. The only fact well aſcertained reſpecting theſe different farinas, ſo different from that of wheat, is, that none of them forms like the latter a real dough, coheſive and ductile, nor affords a ſimilar quantity of glutinous matter, when waſhed with water, added by degrees. We hardly find any traces of it in the farinas of rye and of barley, which, however, approach the neareſt to that of wheat in their property of forming dough, by the tenacity and coheſion which they acquire by kneading. We find no veſtige of it in the farina of rice, of maize, of millet, &c. We eaſily judge of the ſmall proportion of the gluten contained in theſe different ſpecies of farina, by the nature of the dough, which is obtained by kneading them. The leſs they contain of it, the more the dough which they yield is dry, brittle, not ductile, difficult to be kneaded, the more it cracks, dries, and becomes covered at its ſurface with a brittle cruſt; the leſs they alſo riſe when kept at a temperature of fifteen degrees.

12. The property of forming a good dough is ſo cloſely connected with the preſence of the gluten in the farina of wheat, that this farina itſelf preſents variations in this property relative to the quantity of this matter which it contains. In fact we may judge of the goodneſs of this farina, of the maturity and of the

good qualities of the corn which furniſhes it, either by the manner in which it comports itſelf in kneading, or which is a much more certain method than the firſt, by the proportion of glutinous matter that is extracted from it by the proceſs which I have deſcribed. Chemiſts have already found remarkable differences between the various kinds of farina of wheat, according to their qualities, the nature of the corn, that of the ſoil in which it has been reared, that of the year, and the ſeaſons in which it has vegetated; and it were much to be wiſhed that their reſearches relative to this ſubject might be further proſecuted, as they may afford a ſure means of diſtinguiſhing the qualities of the farina, and determining their nutritive properties. Beccari has already obſerved, that the proportion of the gluten varies in the farina of wheat from a fifth to a third. In proportion as the farina of wheat is altered and deteriorated, which happens, as it is known, when it is kept too much compreſſed, without being ſtirred and aired, in hot and moiſt repoſitories; in proportion as it becomes heated, as it aſſumes odour, in a word as it ferments, its property of affording gluten is at the ſame time diminiſhed; and when it is very much altered, it affords only ſome detached flakes, which can no longer be made to cohere, of which we can no longer form a ſingle maſs, a ductile whole. Accordingly this very eaſy and ſimple operation of extracting the gluten of the farina, becomes a rigorous and exact teſt for aſcertaining the goodneſs, the quality, and the good or bad ſtate of this uſeful matter.

C. *Phyſical Properties.*

13. The glutinous principle, when properly prepared, reſembles no other vegetable matter; it is ſoft, tenacious, adheſive to the touch when the fingers are dry, elaſtic, ſuſceptible of elongation when it is drawn, and returning to its former ſtate when left at liberty; of a greyiſh colour, of a faint taſte, and of a ſmell nearly reſembling that of the human ſperm, or that of ſcraped bones when violently rubbed.

14. The elaſtic property of the gluten is that which characterizes this ſubſtance in the moſt ſingular manner. When lengthened with the hand, it becomes flat and thin as it is ſtretched; it aſſumes the appearance of a white, brilliant and ſilky membrane, like the aponeuroſes, or the membranes of animal bodies. It then exhibits a fibrous texture, the filaments of which ſeem to be interwoven with and croſſing each other.

15. Its gluey property and the ſtrong adheſion which it contracts with many bodies, is alſo one of its moſt marked characters. When we attempt to detach it from any ſubſtance upon which it is depoſited, it is extended into filaments detached from each other, and reſembling the texture of felt: its mere aſpect is ſufficient to ſhow its reſemblance with the animal ſubſtances

ſtances, with which it is found to have a ſtriking analogy. It becomes brittle by deſiccation, and then it reſembles glue.

16. The glutinous matter aſſumes a yellow and brown colour, and ſeems to become covered with a layer of oil, by expoſure to the light. When it is expoſed to a gentle fire, it riſes, ſwells, ſeparates and becomes filled with cavities or bubbles; at laſt it dries, without aſſuming much colour, and preſerving the grey caſt which diſtinguiſhes it: it becomes brittle and unalterable by the air, like glue, and all its ductility and elaſticity diſappear. When placed upon a burning coal, this dry gluten becomes agitated like an animal fibre, fuſes, kindles, and burns, ſwelling at the ſame time with a fetid odour. If it be diſtilled dry in a retort, it furniſhes little ammoniacal water, a large quantity of brown, fetid, and thick oil, much ſolid and cryſtallized carbonate of ammonia, a little pruſſic acid, likewiſe in the ammoniacal ſtate, with oily carbonated hidrogen gas; and there is left a coal difficult to be incinerated, and in pretty conſiderable quantity, ſince it amounts to nearly one fifth of the weight of the glutinous matter. Theſe products have all the diſagreeable ſmell of animal ſubſtances ſubmitted to diſtillation; ſo that they might be confounded together, and it is very apparent why the firſt authors termed this ſubſtance the *vegeto-animal matter*.

17. Expoſed to the air, the gluten dries when the weather is very dry and the ſub-

ſtance in ſmall layers: when the air is moiſt, and the gluten in a maſs, it changes, and putrefies, ſwelling at the ſame time like animal matter. When it is not intirely deprived of ſtarch, when it retains any between its particles, the latter paſſing into the acid fermentation, and retarding the putrefaction of the glutinous matter, reduces it to a ſtate very near reſembling that of cheeſe. Roulle the younger, in his courſe of lectures, exhibited glutinous matter thus prepared, and preſerved by means of ſalt, in a kind of cheeſe ſimilar to that of Gruyere, or of Holland, in its texture, its ſmell, and its taſte.

18. Water does not diſſolve gluten, but even prevents its adheſion to the bodies with which it has the greateſt diſpoſition to cohere. The glutinous matter is preſerved for ſome time under water, in order to prevent the drying of its ſurface, and its alteration by the air. When we boil water upon this ſubſtance, it contracts, and becomes more ſolid than it was before: ſo far from being divided and diſſolved, it ſoon loſes its viſcidity and extenſibility. When we compare this action of the water with that which it exerts upon the molecules of the pulverulent gluten of the farina, which it reduces in ſome meaſure to a ductile ſtate, we ſee that this matter, in the latter ſtate, is ſaturated with water, and cannot imbibe any more.

19. All the acids much diluted with water, even thoſe that are the moſt feeble in their

nature,

nature, ſuch as the acetous acid, ſoften the glutinous matter, diſſolve it, and ſuffer it afterwards to be precipitated by the alkalis, but in the form of a matter that has loſt its ductility, and which Macquer imagined to approach to the nature of the mucilages. When the acids are concentrated they act in a very different manner upon this body. The ſulphuric acid gives it a violet colour, blackens it, carbonates it, diſ-hidrogenates it, ſo far as to diſengage from it a very inflammable gas, and to convert it partly into acetous acid, and partly into ammonia. The nitric acid diſengages from it in the cold, azotic gas, as from animal ſubſtances, turns it yellow, converts it in part into malic and oxalic acids, and into yellowiſh, oily, or fatty flakes: this preſents another analogy with the animal ſubſtances. The muriatic acid acts upon it as ſlowly as the ſulphuric acid does quickly, and after remaining long in contact with it, the fluid contains muriate of ammonia.

20. The alkalis when pure, and a little concentrated, diſſolve the gluten with the aid of heat; we may precipitate it from them by the acids, but altered, and no longer elaſtic. When highly concentrated, they convert it into a kind of ſoap, giving it the oily character, and diſengaging from it ammonia, of which they occaſion the inſtantaneous formation, when they are triturated with the gluten. The ſalts, if we except the ſuper-oxigenated muriate of pot-aſh,

which, by mere preſſure, burns and inflames it with detonation, have no other action upon it than to preſerve and to defend it againſt its ſeptic alteration. The metallic oxides, which it reduces more or leſs, decompoſe it by burning, as do alſo the metallic ſolutions.

21. All theſe properties ſhow that the gluten is a ſubſtance very different from the other immediate materials of vegetables, that it approaches very much to the nature of the animal ſubſtances, that it comports itſelf as they do with fire, air, the acids, and the alkalis, eſpecially that it yields ammonia and oil, no leſs abundantly than ſeveral of thoſe ſubſtances; and that beſides the hidrogen, the carbon, and the oxigen which it contains, like all the other vegetable matters, it contains amongſt its elements azote, which ſingularly changes its properties, and gives it all thoſe by which it approaches to the animal compounds.

E. *Species.*

22. NOTWITHSTANDING all that chemiſts have advanced for forty years paſt concerning the glutinous matter, which was diſcovered nearly at that period, and concerning its exiſtence in different vegetables, and in different parts of plants, it is very certain that it is only from the farina of wheat that it has been extracted in the ductile, elaſtic, extenſible, and ſoft form which characterizes it. It ſeems even

in this reſpect that this plant, the general aliment of ſo great a part of mankind, differs remarkably from all other known vegetables, as it is the only one that affords this ſingular product.

23. In order, however, to follow what the moſt able chemiſts have announced or ſuſpected concerning the preſence of the glutinous matter in ſeveral other vegetables, I ſhall enumerate as ſpecies,

A. The elaſtic gluten of the farina of wheat.

B. The filamentous or flakey gluten of other cereal farinas, eſpecially that of which ſome traces are found in barley, in rye, and in oats.

C. The glutinous matter of the green fecula of plants, announced by Rouelle the younger, but not exactly proved; that of linen.

D. That which Citizen Joſſe aſſerts he has extracted from opium, by treating it with water in the ſame manner as the dough of flour.

E. The portion of gluten indicated in the ſweet or acid ſaps by Citizen Deyeux.

F. Bird-lime, prepared, as is well known with the fruits of the miſletoe, with the tender bark of the elm and of ſeveral other trees macerated in water. Though this ſubſtance has not yet been examined with ſufficient attention, it preſents many properties analogous to thoſe of the glutinous ſubſtance.

24. I ſhall

24. I ſhall add to this enumeration, that there is prepared in pharmacy, under the very improper and erroneous name of paſte of mallows, a ſort of tenacious, ductile, elaſtic, and as it were glutinous matter, with a ſolution of gum thickened with ſugar, and mixed with white of egg well beaten up; in fact, this mixture is ſoluble in water, though with difficulty. Finally, I ſhall obſerve, that the particular ſpecies of vegetable matter known by the name of caoutchouc, or elaſtic gum, has many of the characters of the glutinous matter, as I ſhall ſhow hereafter.

F. *Uſes.*

25. It has been thought, from the compariſon of the gluten with the animal matters, that this ſubſtance had more eſpecially the nutritive and reſtorative property, that it formed the baſe of the nouriſhment of men who live particularly upon bread, and that in this conſiſted the advantage of wheat over the other alimentary plants. However, the gluten alone, when preſented to animals, is either rejected by them, or it very ſoon diſguſts them; and it appears to be neceſſary that it ſhould be attenuated by fermentation and combined with the amylaceous matter, in order properly to anſwer this important purpoſe.

26. The glutinous matter is ſometimes uſed for glueing together fragments of porcelain,

glaſs, and pottery: it was employed for this purpoſe in France long before it had been extracted and examined chemically. It is ſeparated in the laboratories of chemiſtry for the purpoſe of examining its properties and characters. It is not yet known either to what part of the ſeed it belongs in wheat, or what functions it performs in germination, fructification, or vegetation.

ARTICLE X.

Of the Seventh of the immediate Materials of Vegetables; of the Extract or Extractive Matter.

A. *Situation.*

1. THOUGH the name of extract was at firſt applied in pharmacy to all the ſubſtances that were ſeparated or extracted from vegetables; though this expreſſion, which is purely pharmacological, has been particularly appropriated to deſignate medicinal products, as the vegetable analyſis has long been excluſively applied to the preparation of medicines, yet the firſt pharmaceutical chemiſts of more or leſs note, who have occupied themſelves with deducing chemical reſults from pharmaceutical operations, have diſtinguiſhed ſome principal kinds of extract

extracts amongſt thoſe which they prepared for medicinal uſes.

2. Thus Rouelle has diſtinguiſhed three principal kinds of extracts, the mucous, the ſaponaceous, and the reſinous extracts. But it is evident from the expoſition of the characteriſtic properties which he attributed to each of theſe extracts, that they are real mixtures of ſeveral of the materials of vegetables which are the cauſes of theſe differences, and that though this diſtinction was of utility for diſcriminating and ſeparating the extracts pharmaceutically prepared, it was, nevertheleſs, adapted only to produce a real confuſion of ideas under the chemical point of view.

3. Independent of this diſtinction, which is more luminous for pharmacy than for chemiſtry, we ought to conceive that the extractive is a particular matter, neither mucous, nor ſaponaceous, nor reſinous, but merely mixed with one or other of theſe ſubſtances, either by the work of Nature herſelf, or by the proceſſes which are employed for obtaining it; that it may be ſeparated from theſe bodies with more or leſs difficulty by chemical means; and that when thus purified, it poſſeſſes properties very characteriſtic, and very different from all the other immediate materials of plants. One of its moſt marked characters is, that it is found united or mixed with ſeveral different ſubſtances, and never exiſts pure in vegetables.

4. The extract, conſidered under this point of view, exiſts in many parts of plants, and its ſeat ſeems to be every where or in ſome reſpect indifferent: however, it is particularly found in the green or brown coloured ſolid parts. Thus the fibrous roots, the trunks and the ſtalks, the barks, the leaves, the fruits afford it in greater or leſs abundance: and on this account it has been propoſed to make extracts from all plants, and from all their parts, eſpecially in a medicinal point of view; and in fact, with the intention of cauſing the virtues o the vegetables to paſs into, to be preſerved and even concentrated in this preparation, which was termed extract, only becauſe it was conſidered as a kind of epitome of the plants themſelves.

B. *Extraction.*

5. As the extract is a matter ſoluble in water when it is pure and without alteration, it exiſts naturally diſſolved in the juice or the ſap of plants, ſo that it is ſufficient to evaporate theſe liquids with a gentle heat, and till they aſſume the ſolid form, in order to reduce them into extracts; in this ſtate they are ſometimes termed inſpiſſated juices, ſuch as opium, aloes, the juice of acacia, that of the hypocyſtis, of ſloes, the cachou, the extract of borage, and a number of other juices inſpiſſated by the nature

of the climate and the ſun, or by the artificial heat of ſtoves, ovens, &c.

6. Frequently the extractive matter, inſpiſſated by the progreſs of vegetation itſelf, is found in plants in a ſolid ſtate. It is more eſpecially in the roots, the wood, the barks, the ligneous and dry leaves, that the extract exiſts in this ſtate. In theſe caſes, chemiſts have applied cold or hot water to theſe vegetable ſubſtances, and continued this application, till the liquid paſſed off without colour or taſte. This water, when once charged with extractive matter, is evaporated by a gentle heat till it leaves a dry matter, which is the extract.

7. The extracts that are prepared in pharmacy receive different modifications from the artiſt, accordingly as the different mixtures which they contain are more or leſs ſuſceptible of being altered, or of remaining without alteration; for theſe preparations, made in order to be preſerved, ought to be put into a condition not to be decompoſed ſpontaneouſly. On this account, thoſe which are mucous or fermentiſcible are more ſtrongly inſpiſſated or evaporated than thoſe that are bitter and more or leſs reſinous. Hence the different forms and conditions which are given to theſe preparations; ſome are ſoft and like honey; others thick, hard, and dry as the cachou, the juice of liquorice; others in thin, dry, and brittle ſcales, as their ſolution has been evaporated upon plates by the heat of a ſtove: hence the expreſſions of *rob, ſapa; defrutum,*

defrutum, *eſſential ſalts* of Legaraie, which all have only relative, and often erroneous values. It is even uſeful here to remark, that the greater number of the pharmaceutical extracts are more or leſs altered, burned, or reduced to coal, by the kind of evaporation itſelf, violent and long continued, which they are made to undergo; and that thoſe which have been evaporated ſlowly, have experienced from the atmoſpherical oxigen, another kind of alteration of which I ſhall ſoon ſpeak.

C. *Phyſical Properties.*

8. The pure extract is a ſolid, lamellated, and tranſparent body, when its ſolution has been evaporated in thin layers, or granulated, and in opaque maſſes when its ſolution has been treated in large quantity by ſtrong evaporation, of a brown, more or leſs red or deep coour, of a taſte almoſt always more or leſs ſenſibly bitter, or acrid, or acerb, and always acid.

9. It is ſo rare for the extractive matter to be inſulated in the common extracts, that the properties which I have juſt indicated in it are ſuſceptible of a multitude of modifications or variations which prevent their characters being deſcribed in an unequivocal manner. However, in ſeeking thoſe characters which have appeared to me to belong in a ſpecial manner to the extractive matter, I have found that its aſſuming the brown colour, and its property of abſorbing oxi-

gen which renders it inſoluble, were thoſe which ſeemed to belong to it excluſively; that afterwards its taſte, its conſiſtence, its more or leſs conſiderable alterability were modified in it in a very various manner, according to the different quantity and nature of the matters that were naturally combined with it.

D. *Chemical Properties.*

10. The extract is not in the ſame predicament with the moſt of the other immediate materials of vegetables; but it has ſo long been confounded with ſome of them; and mixtures, or combinations of ſeveral of theſe bodies have ſo long been taken for it, that its chemical properties have not been eaſily determined, and it is impoſſible for me to ſet them forth in the ſame order, or with the ſame method as that which I have hitherto followed for the other materials. I have, however, been the firſt who have endeavoured to diffuſe ſome light over this part of the vegetable analyſis, which has hitherto been ſo obſcure and ſo much neglected, as may be ſeen in my Examination of the Cinchona of St. Domingo, inſerted in the Annals of Chemiſtry. Since that time, Citizen Vauquelin has reſumed this uſeful inquiry, and carried it much further. In order to afford an idea of the manner in which he has ſucceeded in determining the chemical nature of the extract, I ſhall here follow him in the ſeries of obſervations

and experiments which have guided him in this inquiry, pointing out what relations ſubſiſt between his labours and that which I had deſcribed at firſt in the work already mentioned.

11. It was by examining the ſap of trees that this chemiſt was conducted to the knowledge of the extractive matter. By conſidering this principle diſſolved in the water of vegetation, he remarks that this liquid, which is colourleſs at the moment when it comes from its canals, aſſumes a more or leſs brown caſt by expoſure to the air; that the expreſſed juices of plants alſo become brown or yellow by the contact of the air and the light; that during their evaporation there is formed at their ſurface a brown or reddiſh pellicle which breaks into flakes, that ſimilar brown flakes preſent themſelves in the midſt of theſe liquids, that this phenomenon taking place equally in the preparation of pharmaceutical extracts, the flakes in queſtion are confuſedly mixed in them with the dried extract, and that when we diſſolve this in water there always remains a portion of brown or blackiſh matter which does not diſſolve; that the longer the evaporation is continued, the more points of contact there are between the air and the extractive liquor, and the more inſoluble matter is formed; ſo that by continuing the ſucceſſive ſolutions and evaporations of the extract, it cannot be doubted that we may at laſt render the whole of this body flaky and inſoluble. Theſe firſt facts intirely agree with what I

have ſaid concerning the product of the decoctions of Cinchona of St. Domingo, and of the nature of the extract in general, the principal character of which conſiſts, according to to me, in its abſorption of oxigen and the inſolubility conſequent thereupon.

12. The ſolutions of all the pharmaceutical extracts redden the tincture of turnſole. Every ſolution of extract prepared by the evaporation of the juice of a plant yields, by ſome drops of ammonia, a precipitate of a more or leſs deep brown colour, formed of lime and the extractive part become inſoluble. The concentrated ſulphuric acid thrown upon an extract, diſengages from it a very penetrating acid vapour, and we extract from it weak acetous acid, by diſtilling the mixture of one part of extract with half a part of ſulphuric acid diluted with four parts of water. Thus the extracts contain free acetous acid, which renders their taſte ſour, which cauſes them to redden turnſole, and combined acetous acid, which the ſulphuric acid diſengages from them in much greater abundance. When we mix quick-lime in powder with an extract ſteeped in a little water, a pungent vapour of ammonia riſes, which may be obtained from it by diſtillation. If, after having diſtilled an extract with ſulphuric acid, in order to ſeparate the acetous acid from it, we treat the reſiduum with alcohol, which diſſolves the extract, we find in the reſiduum

ſulphate of pot-aſh, ſulphate of lime, and ſulphate of ammonia.

13. It is evident, from the facts, that beſides the mucilage, the ſaccharine ſubſtance, the gelatin, the different vegetable acids, the reſin, which are ſo frequently mixed with the extractive matter in the pharmaceutical extracts, they conſtantly contain acetous acid, acetites of pot-aſh, of lime, and of ammonia. It is alſo known that they frequently contain ſulphate of pot-aſh, muriate of pot-aſh, and ſulphate of lime, the exiſtence and proportion of which may be determined by examining them before treating them with the ſulphuric acid, and comparing the proportion of theſe ſaline products with that which they furniſh after the addition of this foreign acid. To theſe muſt alſo be added the nitrate of pot-aſh, which is found ſo abundantly and ſo frequently in the juices of plants and in their extracts. It is true that this appears to proceed from the ſoil itſelf in which they are rooted.

14. Theſe firſt facts ſtill belong only to the matters which pretty conſtantly accompany the extracts, and are not eſpecially characteriſtic of this principle. However, by calling to recollection that thoſe which I have already attributed to it, are its aſſuming a brown colour by the contact of the air, its precipitation and ſeparation from water, in pellicles, or in inſoluble coloured flakes, by the abſorption of oxigen, and the precipitation of the juices which

have ſaid concerning the product of the decoctions of Cinchona of St. Domingo, and of the nature of the extract in general, the principal character of which conſiſts, according to to me, in its abſorption of oxigen and the inſolubility conſequent thereupon.

12. The ſolutions of all the pharmaceutical extracts redden the tincture of turnſole. Every ſolution of extract prepared by the evaporation of the juice of a plant yields, by ſome drops of ammonia, a precipitate of a more or leſs deep brown colour, formed of lime and the extractive part become inſoluble. The concentrated ſulphuric acid thrown upon an extract, diſengages from it a very penetrating acid vapour, and we extract from it weak acetous acid, by diſtilling the mixture of one part of extract with half a part of ſulphuric acid diluted with four parts of water. Thus the extracts contain free acetous acid, which renders their taſte ſour, which cauſes them to redden turnſole, and combined acetous acid, which the ſulphuric acid diſengages from them in much greater abundance. When we mix quick-lime in powder with an extract ſteeped in a little water, a pungent vapour of ammonia riſes, which may be obtained from it by diſtillation. If, after having diſtilled an extract with ſulphuric acid, in order to ſeparate the acetous acid from it, we treat the reſiduum with alcohol, which diſſolves the extract, we find in the reſiduum

ſulphate

the ſolution, which we may intirely exhauſt of extract by repeating or urging this proceſs. We may ſucceed ſtill better in totally ſeparating the water and precipitating the colouring matter of the extract in a ſolid form upon the cloths, by ſoaking wool, cotton, or thread, for ſome time in oxigenated muriatic acid, and afterwards immerſing them in a ſolution of extract: the oxigen abandons the acid, ſeizes the extract, takes it away from the water, and precipitates it upon the cloth, which alſo exerts a particular attraction upon it.

17. All the extracts, whatever they may be, when ſubjected to diſtillation, yield an acid product, in part ſaturated with ammonia, which contains much more of the latter body than is ſeparated by means of lime or the alkalis. Thus the extract, beſides the portion of ammonia that exiſts ready formed in it, contains alſo the materials of this alkali, which unite by the action of the fire. When ſolutions of extracts in water are left alone, the extractive is ſpontaneouſly decompoſed in them in the courſe of time; the liquors become turbid, depoſit abundant mucous flakes, become covered with different kinds of moulds, diffuſe various odours, yield ammonia, and leave at laſt for fixed products of this putrefaction, carbonates of pot-aſh and of lime.

18. From a compariſon of all theſe facts we may deduce the following reſults:

a. The pharmaceutical extracts are complex ſubſtances, compoſed of very heterogeneous matters, ſome of which are pretty conſtant, and the others accidental, dependent frequently upon the nature of the ſoil in which the vegetables have been reared.

b. The ſubſtances which conſtantly accompany the extractive matter in the pharmaceutical extracts are free acetous acid, the acetites of potaſh, of lime, and of ammonia. Thoſe which are accidental in them vary in ſuch a manner according to a multitude of different circumſtances, that it is impoſſible to give a ſtatement of them; all the immediate materials of plants that are ſoluble in water belong to this order of accidental bodies in the extracts, and may be found in them one or more at a time: it was according to theſe that Rouelle had made his three claſſes of extracts, but they are very incomplete, inſufficient, and inaccurate.

c. The extract, conſidered ſeparately from all the ſubſtances foreign to its nature, whether conſtant or accidental, is a ſubſtance very different from all the other immediate materials of vegetables; it is characterized by its attraction for oxigen, the manner in which it abſorbs it from the air, from the oxigenated muriatic acid, from the metallic oxides, by the inſolubility which it acquires by combining with it, by the brown colour which it aſſumes in proportion as it unites with it, by its union with alumine, with the metallic oxides, and by its adheſion to cloths by the aid of theſe mordants, by the ſeparation of the water, effected by the acetite of lime, which is conſtantly mixed with it, and of the ammonia which is added to it; a ſeparation, which is owing to the double elective attraction of the lime for the extractive matter, with which it is precipitated in an inſoluble ſtate, and of the ammonia with the acetous acid.

d. The extractive matter is a kind of oxide with a triple radical, or a compound of carbon, of hidrogen, of azote, and of oxigen, which is not ſaturated with the laſt of thoſe principles, but can abſorb much more than it contains. It approaches very nearly in its properties to the matter which dyers term *colour*, or *colouring matter*, from which it differs only in the proportion of its primitive principles.

e. The property which the pureſt extracts poſſeſs of attracting the humidity of the atmoſphere, and of becoming ſoft when expoſed to it, does not belong to the extracts, but only to the acetite of pot-aſh which they contain, and we might even determine by their deliqueſcence the proportion of this ſalt which is contained in them. There is reaſon to believe, that the virtues admitted by phyſicians in the extracts, are owing only to the acetites which are conſtantly combined with them, and depend very little upon the extractive matter, properly ſo called.

19. It is not, however, to be inferred from all theſe facts, that the nature of the extract, ſuppoſing it deprived of all the different matters which it contains, is perfectly identical in all vegetables. On the contrary, it is probable that the proportions of theſe primitive principles vary a little; but that it is not to this primitive variation of principle that we are to aſcribe the very ſtriking difference of the virtues which phyſicians have obſerved in opium, the extract of cinchona, that of the wild cucumber, of belladonna, of hemlock, of ſtramonium, ſubſtances ſo different from one another, but that it is rather to ſome particular matters added, in each of theſe bodies, to the extractive, properly ſo called, that their different modes of acting ought to be attributed.

E. *Species.*

20. It muſt appear, from what has been obſerved in the preceding numbers (8 to 19,) that the number of the ſpecies of extracts may be very conſiderable, if we ſhould wiſh to eſtabliſh between them diſtinctions founded upon their individual properties. It would then be neceſſary to admit as many of them as there are different plants capable of furniſhing them. According to each particular matter added to the extractive, it would then be neceſſary ſingularly to multiply this claſſification of the

extracts; on the other hand, if we were to conſider the extractive matter, properly ſo called, abſtractedly from all the ſubſtances that may be added to it, we ſhould then not be in poſſeſſion of a ſufficient ſtock of knowledge to diſtinguiſh with preciſion the real difference which ſeparates them the one from the other.

21. By holding a ſort of middle courſe between the two limits which the ſcience cannot yet attain, we may continue to employ, but only for pharmaceutical uſes, the diſtinction admitted by Rouelle, namely:

A. *Mucous* inſpiſſated juices or extracts, amongſt which are to be ranked the rob of currants, the juice of liquorice, the extract of juniper.

B. *Saponaceous* inſpiſſated juices or extracts, to which are to be referred the juice or the extract of borage, the juice of the acacia, that of hypociſtis, of ſloes, cachou, and the extract of Peruvian bark.

C. *Extracto-reſinous* inſpiſſated juices or extracts, which preſent amongſt their moſt remarkable ſpecies, opium, a very complicated juice, containing, with the extractive matter, an oil and a viſcid reſin, a mucilage, a gluten, and a ſalt; aloes, improperly ranked amongſt the gum reſins, the elaterium, or juice of the wild cucumber; and the extract of rhubarb.

22. We are ſtill far too much in want of experiments upon the pharmaceutical extracts to be able to claſs even conveniently, though ſtill

with little accuracy, under one or other of theſe three diviſions, the moſt of thoſe that are prepared and employed in medicine; ſuch as the extracts of gentian, of water-trefoil, of elecampane, hemlock, of belladonna, of pulſatilla, of chervil, of fumitory, of patience, of centaury, of ſuccory, of tormentilla, of ſaffron. I have here mentioned only the principal and the moſt commonly employed of theſe preparations, as the diſpenſatories contain a number of others equally unknown with reſpect to their claſſification.

B. *Uſes.*

23. A MUCH greater uſe was formerly made of extracts in medicine: at preſent, twenty ſpecies at moſt are employed in pharmacy, including thoſe which are prepared in the large way in commerce. We have ſeen that for the greater part, excepting thoſe that are acrid, narcotic, poiſonous, or violently aſtringent and febrifuge, their principal virtues, which are aperient, diſſolvent, and purgative, may be attributed to the acetite of pot-aſh which they contain.

24. We may add to this medicinal uſe, regarded hitherto as the only one in all the works on chemiſtry, that there is another which is much more frequent, and much more important for ſociety, namely, that which is made of the extracts in dyeing. All thoſe ſubſtances which dyers call colours of roots, or even of woods,

are nothing elſe but extracts in ſolution, in which they dip and keep immerſed for a longer or ſhorter ſpace of time during their ebullition, threads and ſtuffs previouſly impregnated with ſolution of alum, or ſome other mordant, in order to precipitate and fix upon them the extractive matter. I ſhall revert to this ſubject in one of the ſubſequent articles.

ARTICLE XI.

Of the Eighth of the immediate Materials of Vegetables; of the Fixed Oils.

A. *Situation.*

1. OIL, or the oily ſubſtance, in general, is one of the immediate materials of vegetables, the leaſt ſoluble in water, and is eminently diſtinguiſhed from all others by its combuſtible property, and by the bright flame which it emits during its combuſtion. It is long ſince it was firſt remarked that the oil formed by vegetables is one of the products of vegetation, that there is no mineral oil, properly ſo called, and that what is ſometimes found amongſt the foſſils originates from plants, and cannot be compoſed in the bowels of the earth.

2. The ſpecial and diſtinctive character of fixed oil is, that it is not raiſed eaſily, and without alteration into vapour by the action of fire; and it is oppoſed by this character to volatile

oil. It was formerly termed fat oil, *oleum unguinoſum*, or mild oil, as it enjoys both theſe properties; and expreſſed oil, becauſe it is conſtantly obtained by expreſſion.

3. Amongſt the properties by which it is diſtinguiſhed, I eſpecially remark that of being contained only in a ſingle part of the vegetables; namely, in their ſeeds. It would be in vain to look for it in other organs; it is never found either in the roots, the ſtalks, the barks, the leaves, or the flowers. Sometimes, though rarely, it is ſituated in the parenchyma, or the pulp of certain fruits; moreover, amongſt the numerous oleiferous plants of our climates only the olive can be mentioned, as containing it in its ſoft external ſkin, and on the outſide of its kernel. Generally it exiſts only in the cotyledons, and it is even found only in thoſe that have two cotyledons. I know no example of a monocotyledonal plant with an oily ſeed.

4. All the dicotyledonal ſeeds that contain oil, are at the ſame time charged with mucilage and fecula, and they have all a character by which they may be diſtinguiſhed; namely, that of forming with water in which they are triturated, a white liquor which is termed emulſion, milk of almonds; on which account they are termed emulſive ſeeds. They manifeſtly owe this property to the oil which they contain between the particles of their parenchyma. The water, by diſſolving the mucilage, and diſperſing in ſome meaſure between its own par-

ticles, thoſe of the ſtarch, retains in ſuſpenſion ſmall drops of oil, which deſtroy its tranſparency, and give it a milky opacity and whiteneſs. Accordingly, when this milk of almonds is kept for a long time in contact with the air, a portion of the oil ſeparates at its ſurface in the form of a greyiſh or ſemi-tranſparent cream; this layer ſeparated at the ſurface, forms, even at the end of ſome days, real oily drops. During this ſeparation a portion of the fecula is depoſited in a white powder, and the liquor becomes clear in proportion as this double ſeparation of the two ſubſtances, that were diſſeminated in it, is effected by repoſe. The acids bring about this kind of decompoſition in a much more ſpeedy and powerful manner.

5. This excluſive preſence of the fixed oil in the interior of the dicotyledonal ſeeds, is a fact that has not yet ſufficiently engaged the attention of chemiſts. It may, however, throw ſome light upon ſeveral parts of vegetable phyſics, as it manifeſtly depends upon the ſtructure, the intimate nature, and the functions of the ſeeds. I ſhall content myſelf with obſerving here, in a general manner, that the fixed oil, which is mild and nutritious, accompanies the embryo in the ſeed like the chick in the egg: that it is ſituated in a particular place in theſe ſeeds, like the oil of the egg in the yolk; that it gives to the maſs of cotyledons the property of forming with water a kind of vegetablem ilk, like that the egg gives to the yolk,

the property of forming with water what is termed pretty accurately *lait de poule*; finally, that it contributes, in the period of germination, to the firſt nouriſhment of the plant, as the yolk ſerves for the nutrition of the chick during incubation, and previous to its leaving the egg, and that it ſeems to characterize the dicotyledonal plants in oppoſition to the monocolytedonal, in the ſame manner as the oviparous animals, whoſe young enjoy only this kind of lactation in the egg, are oppoſed to the viviparous, which receive milk from the mother after they have left the uterus.

B. Extraction.

6. Fixed oil being contained ready formed in the parenchyma of the ſeeds, or of ſome fruits, nothing more is required than to preſs this parenchyma more or leſs forcibly, in order to make it run out, and to obtain it ſeparate. But the manner itſelf in which it is contained or incloſed in the parenchyma, its abundance compared with that of the other ſubſtances that are mixed with it, or with which its particles are ſurrounded, its more or leſs liquid ſtate, and its greater or leſs diſpoſition to run, are many circumſtances that muſt influence the art of extracting it, and determine modifications in the practice of this art.

7. Frequently nothing more is neceſſary than to bruiſe the ſeeds, reduce them to a kind of pulp or cake, afterwards to ſubject this paſte,

incloſed in ſacks of hair, or cloth, to the action of the preſs, in order to cauſe the oil to run out in ſuch a manner that it can eaſily be collected. This is the operation practiſed in the pharmaceutical laboratories, in order to obtain the oil of almonds, and the oil of linſeed; they are then termed cold-drawn oils, and a ſimilar or equally ſimple proceſs is followed for extracting the oil of hazelnuts, of walnuts, of hemp-ſeed, of colza, of rape ſeed, even the oil of olive, the oil of beech-maſt, the oil of poppy ſeed, and a great number of others analogous to theſe in their nature and their uſes.

8. But it is obſerved that moſt of the ſeeds yeild by this proceſs only a ſmall quantity of oil, and that though it is very pure, and very mild, ſuch as is requiſite for medicinal uſes, it is too dear on account of its ſcarcity for moſt of the purpoſes of life, or the arts for which it is deſtined. We even meet with ſome ſeeds, which, containing together with the oil, a more or leſs conſiderable quantity of gummy mucilage, or of light and highly divided fecula, yield hardly any oil by the mere preſſure of their paſte in the cold, or elſe yield it only with extreme difficulty. Thoſe even from which all the mild and fixed oil which they are capable of affording, has been extracted by the firſt proceſs, ſtill retain a portion in ſufficient quantity for it to be poſſible to obtain much from them by a ſecond manipulation.

9. In the caſe which I have juſt indicated, a more or leſs violent heat is employed, according to the ſubſtances which we have to treat, according to the more or leſs condenſed nature of the oil which they contain, of the fecula, or of the mucilage, of the receptacle, from which they muſt be extracted, according to the more or leſs important uſes to which they are deſtined. Sometimes we content ourſelves with heating plates of block tin, which are applied immediately to the paſte of the ſeeds, and which compreſs them by the approximation of the peices of the preſs, in order to give more fluidity to the oil, as is done with the ſweet almonds; at other times the paſte itſelf is expoſed to the vapour of boiling water, in order to penetrate it with a gentle heat, which favours the ſeparation and the eſcape of the oily juice. For the leſs important oils, the ſeeds are more or leſs ſtrongly roaſted, in order to thicken or dry their mucilage and fecula, to bring the oily molecules to their ſurface, and to begin to cauſe the drops to exſude outwards. This laſt proceſs is particularly employed for the very mucous and very viſcid ſeeds, which at the ſame time contain a large quantity of water. The oils that are extracted by this manipulation, which is employed for linſeed, and hemp-ſeed, are leſs pure, leſs mild, and leſs fine than the firſt; they are alſo more coloured; but they are at the ſame time more abundant and more eaſily preſerved. When

the ſeeds have been too much roaſted, the oil is reddiſh and has a more or leſs ſtrong empyreumatic taſte.

10. The fixed oil that is obtained by the proceſſes that have been indicated, is always mixed, and even combined with ſome foreign ſubſtances, and eſpecially with mucilage, amylaceous fecula, and colouring matter. Frequently theſe three bodies, and eſpecially the two latter are ſpontaneouſly depoſited from the oily liquid, when it is kept at reſt for ſome time; we ſee mucous flakes, coloured fibrils, or ſlight feculent powders gradually precipitated to the bottom of theſe oils; theſe, which at firſt were opaque or turbid, at the moment when the action of the preſs expelled them from the paſte of the ſeeds, become clear, and more or leſs tranſparent and pure when left to themſelves. The groſs portion of the parenchyma, which has been carried along with the firſt portions of expreſſed oil, is ſeparated and precipitated firſt, afterwards the green and coloured fecula, then the amylaceous fecula; and the gummy mucilage is depoſited the laſt, but frequently there even remains a portion in real ſolution or combination with the oily juice: it is this portion which forms what Scheele has termed the ſweet principle of the oils, of which I ſhall ſpeak hereafter. It is this that gives to the oil, when burned, the thick flakes which render it turbid, and more or leſs diminiſh its combuſtibility. Sometimes a por-

a portion of the green fecula, as we ſee in the oil of olives, remains in ſolution in this body, and communicates to it the colour and the taſte of the fruit.

11. We ſee from what has been ſaid that mere repoſe is not always ſufficient for purifying the oils; filtration through ſieves or linen, with more or leſs wide interſtices for ſeparating the groſſer part, is likewiſe only a mechanical means, which takes away merely the foreign matters which are interpoſed: the effect of time ſeparates indeed, eſpecially with certain oils, a portion of the mucilage or of the light fecula which are diſſolved in them; but there is another part, and ſome oils contain a large quantity of it, which remains really diſſolved in them, and is never ſeparated from them by reſt, at leaſt unleſs the oil itſelf undergoes an alteration, and communicates to theſe bodies properties which oppoſe the combination of advantages which we expect from them. It is eſpecially in order to render them more pure and more eaſily as well as more completely combuſtible that we endeavour, by different proceſſes, to free them from the foreign ſubſtances that are combined with them. Chemiſtry has not yet exactly determined the different ſtates of lamp-oils, and the real cauſes of their bad qualities. The proceſſes alſo that are employed in ſome manufactories or work-ſhops for purifying theſe oils are a kind of empirical practices, or methods which Science has not yet examined.

12. Theſe proceſſes of the arts or of the work-ſhops in which oil is employed are very much diverſified, and frequently conſtitute a kind of ſecret. It appears that in ſome, after having ſuffered the oils to reſt, and filtrated them, they beat them up with water; in others they heat them gently for a longer or ſhorter ſpace of time. There are ſome in which the oils are treated by acids diluted with water; and this proceſs muſt in fact ſeparate the mucilage from them. There are others in which they are treated by lime or the alkalis, which appear to abſorb an acid holding mucilage in ſolution, and to favour the precipitation of this mucilage. It is alſo aſſerted that in ſome work-ſhops they uſe alum, whilſt in others they employ chalk, gypſum, argil, or aſhes for effecting the purification of the oils. It is evident that if each of theſe means ſucceeds, it is to be concluded, that the matters which render the oils impure muſt vary according to the ſpecies; but it is of much greater importance to be obſerved that an accurate chemical examination of theſe liquids will alone enable us to throw upon this ſubject the light which the ſcience is capable of diffuſing over it, and that after ſuch an examination this art ſo uſeful to ſociety will no longer be involved in obſcurity.

C. *Phyſical Properties.*

13. Fixed oil is generally a liquid rather thick or viſcid, forming ſtreaks that adhere to glaſs, of a mild or inſipid taſte, ſometimes a little acerb, or analogous to that of the plant from which it proceeds; without any peculiar ſmell, but frequently alſo impregnated with that of the ſeed from which it has been extracted.

14. Fixed oil is never entirely void of colour; frequently it has a greeniſh or yellowiſh hue: that which is green when recent, loſes this caſt in the courſe of time, and aſſumes a yellow ſhade, which at length becomes deeper and inclines towards the orange or the red. In general it is lighter than water, ſwims upon its ſurface; and its ſpecific gravity, taking that of water at 10000, varies between 9403 for linſeed oil, and 9153 for olive oil.

15. This body, when expoſed to the cold, congeals and even cryſtalſizes, or aſſumes a ſolid and granulated form by cooling; but this property varies in it in a ſingular manner according to the ſpecies: there are ſome that become fixed at five or ſix degrees above 0, and others, on the contrary, are not congealed, unleſs at 10 or 12 degrees below 0; there are even ſome that never become ſolid by the effect of cold. It is generally obſerved that thoſe which become fixed the moſt ſpeedily, like the oil of olives, are the leaſt alterable, the

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leaſt ſubject to change, and that, on the contrary, thoſe which are very difficult to be congealed, are the moſt ſubject to ſpoil, to become rancid, &c.

D. *Chemical Properties.*

16. Fixed oil, expoſed to the fire, is not volatilized unleſs when it is boiling, and hence it derives its name; but in this volatilization it is altered, loſes ſome of its principles, tends to be decompoſed; the carbon is partly inſulated in proportion as the oil is heated; the volatilized portion is more hidrogenated and lighter; water is formed, and an acid analogous to that of the fats, which is termed *ſebacic.* There remains in the retort black and coaly traces; and carbonated hidrogen gas is diſengaged. Such is the collection of the phenomena which take place in the diſtillation of the oils, which the ancient chemiſts performed in order to obtain what they termed the oil of Philoſophers. The volume of the air contained in the apparatuſes contributed alſo to its production in a more or leſs efficacious manner, becauſe there is more water formed, and carbon inſulated, as the capacity of the diſtilling veſſels is larger; ſo that by repeating the diſtillation of the ſame oil a great number of times in new apparatuſes, we at laſt conſtantly reduce it almoſt entirely into water, carbonic acid, carbonated hidrogen gas, and coal.

17. The phenomena of the combuſtion of oils, when heated in contact with the air, are the ſame as the preceding, except that its decompoſition is more rapid and more complete. It is well known that they cannot be burned unleſs when violently heated, that the uſe of the wick employed in lamps is to raiſe the oil in vapour by ſucceſſive portions; that in the ingenious lamp of Argand and Lange, by diſpoſing the wick in a circular form, and ſurrounding it with a double current of air, by increaſing the activity of this by the addition of a tranſparent tube of glaſs round the wick, and eſpecially by giving this tube a contraction at the very place where the extremity of the wick uſually exhales ſmoke, the combuſtion of the oil is rendered much more complete and rapid, the flame more brilliant, the ſmoke and ſmell annihilated, as both are intirely deſtroyed, and that the product of this complete combuſtion is only water and carbonic acid. 100 parts of oil ought to yield 130 parts of water, as they contain, according to Lavoiſier, 21 parts of hidrogen, and 203 of carbonic acid, ſince they contain according to the ſame author 79 parts of carbon; now the ſum of theſe two products being 333, 233 parts of oxigen muſt be added to 100 parts of oil in order to make it burn. This reſult, which certainly is not very accurate, but which approaches to the truth as near as can be, in a firſt experiment, ſuppoſes indeed that there is no oxigen in a fixed oil, that it is

compoſed only of carbon and hidrogen, and it is probable that it includes ſome error in this point of view; but it is certain and well aſcertained that oil is reduced only into water and carbonic acid by combuſtion, and that it affords more water and likewiſe more carbonic acid than its own weight.

18. A very different effect takes place with the fixed oil when expoſed to the air without heating it, as to inflame it; it gradually thickens, becomes concrete, opake, white, granulated and ſimilar to tallow. This change takes place very quickly, and requires only ſome days, if we greatly extend the oil upon the ſurface of water, as Citizen Berthollet has diſcovered. This effect is owing to the oxigen which they ſlowly abſorb; they become a kind of wax; they even experience this alteration in the living vegetables, by a diſpoſition which I ſhall deſcribe in the next article. Some fixed oils become dry, and theſe are termed drying oils. Some undergo the cerification or ſebification very quickly; others, on the contrary, very ſlowly; ſome as they thicken aſſume a ſebacic character which manifeſts itſelf in their taſte and ſmell; they are then rancid, redden the blue vegetable colours, and are unfit to be uſed as food or condiment: there is alſo formed at the ſame time a ſmall quantity of water which appears in ſmall drops at the ſurface, or evaporates into the air. There take place, therefore, in this

ſlow action of the air three very diſtinct effects upon the fixed oils. The firſt is a ſimple abſorption of the atmoſpheric oxigen, which thickens them and tends to convert them into wax; the ſecond is a diſengagement of their hidrogen, which burns at their ſurface, forms water, and dries them themſelves without cerifying them; the third is the production of the ſebacic acid which depends upon a new union, and in a determinate proportion, of hidrogen, of carbon and of oxigen : this conſtitutes rancidity. Every ſpecies of fixed oil experiences in a different manner one or other of theſe effects, ſometimes inſulated, ſometimes combined; ſo that ſome are cerifiable, others drying, and the third rancefcent. There are ſome that do not undergo any of theſe alterations without much difficulty. Theſe different modifications in the alterability of the oils depend upon their primitive combination, or the proportion of their elementary conſtitution, and it will be eaſy to aſcertain their difference and their cauſe, when an analyſis ſhall have been inſtituted of the principal ſpecies that belong to one or the other of theſe genera; for it ſhall be ſhown hereafter that in order to diſtinguiſh the ſpecies it is neceſſary to divide them according to theſe properties.

19. The ſimple combuſtible bodies unite more or leſs eaſily with fixed oil; hidrogen in the ſtate of gas does not unite with it unleſs with difficulty.

Carbon in the ſtate of coal, through which oil is filtrated, contributes to purify or whiten it, without ſenſibly uniting with it.

Phoſphorus unites with the oils by the aid of heat; it fuſes and diſſolves in them in a ſmall proportion, communicating to them the luminous property when they are rubbed in the air; and it is this ſolution which is employed for rendering any ſurfaces luminous and phoſphoric in the dark. When we diſſolve in heat all the phoſphorus which the oil is capable of diſſolving, by letting it cool, a part of the phoſphorus is depoſited by the refrigeration, and cryſtallizes in tranſparent octahedrons. By diſtilling the phoſphorated oil, we obtain phoſphorated hidrogen gas.

Sulphur combines eaſily with fixed oil by means of heat; whence reſults a reddiſh ſolution which has formerly been termed *Ruby of Sulphur*, on account of its colour. This ſolution depoſits cryſtallized ſulphur by refrigeration; it is even the only proceſs by which Pelletier has obtained the ſulphur cryſtallized in octahedrons. When the refrigeration is too rapid, yellow ſulphur is precipitated in needles. If we diſtil this ſulphurated oil, which has a fetid ſmell, a large quantity of ſulphurated hidrogen gas is obtained, without the ſulphur ſubliming in its concrete and inſulated ſtate.

Some oils exert an action upon the metals that are the moſt eaſily oxidated; they accelerate their oxidation, and favour the abſorption of the atmoſpheric oxigen; but this effect is in general feeble and ſlow. The metallic oxides have a much more marked action upon the vegetable combuſtibles; by the aid of heat, they yield a portion of their oxigen to the oils, which then become thickened, and form in general the ſubſtances known by the name of *plaſters*. In this ſtate they form kinds of ſoaps frequently inſoluble, ſometimes more or leſs ſoluble. If we augment this action by that of heat, we intirely decompoſe the metallic oxide; it paſſes again into the ſtate of metal, and the oil is then intirely deſtroyed into water, and carbonic acid. It is this which cauſes plaſters to aſſume a coppery-red colour, and moſt of the ointments, or plaſters, that have been too long boiled, acquire a brown or blackiſh colour, by the reduction of the oxide of lead.

20. Water has no ſenſible action upon the fixed oils; they remain upon the ſurface of this liquid. When agitated with it, they firſt whiten it and interpoſe themſelves between its particles; but they ſeparate again from it by repoſe. Water, however, takes from them a certain proportion of mucilage, and favours the ſeparation of the colouring fecula, which troubles their tranſparency; this is a means uſed in work-ſhops for purifying them and rendering them more combuſtible.

21. The acids are capable of decompoſing the fixed oils, but with particular phenomena, according to the nature and the concentration of

theſe acids, as well as their quantity and different temperature. In general, the concentrated ſulphuric acid renders theſe oils brown, thick, and reduces them to coal. This action has formerly been compared to the formation of a reſin, or of a bitumen; but it is really neither the one or the other; it is a commencement of decompoſition, in which water is formed; carbon is ſeparated and precipitated, and even an acid is produced. The cold nitric acid thickens and ſlightly oxidates them; if it be mixed with nitrous gas, it acts with much greater activity; it excites a conſiderable ebullition and effervefcence, and a large quantity of nitrous gas is diſengaged. When we throw upon oils a mixture of concentrated nitrous and ſulphuric acids, they immediately inflame, and leave a coal more or leſs inflated and voluminous. By employing nitric acid with caution, we may effect the exact analyſis of an oil; we convert it into oxalic acid. The ordinary muriatic acid produces very little effect upon fixed oil; the oxigenated muriatic acid thickens and whitens it like tallow or wax.

22. All the alkalis exert a more or leſs remarkable action upon the fixed oils; they all render it ſoluble, and reduce it to the ſaponaceous ſtate; the name of *ſoap* is even applied in a particular manner to this combination of a fixed oil with an alkali. The medicinal ſoap is made by triturating in a mortar of glaſs or marble, one part of cauſtic ley of pot-aſh, weighing at leaſt one half more than water,

with two parts of oil of ſweet almonds. Trituration in the cold is ſufficient to effect this combination. With oils of inferior quality, and a cauſtic ley of ſoda, a little concentrated and well mixed, the common ſoap is prepared, which becomes ſolid in the courſe of time. Moſt commonly this combination is promoted by heat, in order to concentrate the ley; the liquid portion is afterwards ſeparated; when ley of pot-aſh is uſed only a ſoft ſoap is obtained. That which is termed *marble ſoap*, is made with crude ſoda, ſulphate of copper, cinnabar, &c. The moſt ordinary ſorts, which are termed *green* or black ſoaps, are manufactured with the marc of oil of olive, of nuts, of rape-ſeed, and the cauſtic alkalis treated by ebullition. The reader may conſult, for the economical practice of this art, the inſtruction publiſhed by Citizens Darcet and Pelletier.

23. Soap, properly ſo called, or the combination of a fixed oil, with cauſtic ſoda, is a white, ſolid, acrid and alkaline ſubſtance, very fuſible in the fire, abſorbing a very large quantity of water, which greatly increaſes its volume; loſing this volume and becoming very light by expoſure to dry air, or by a gentle fire, from which the alkali gradually ſeparates in the form of cryſtallized carbonate of ſoda by long expoſure to the air; decompoſable by fire, and yielding its oil, part liquid and part ſolid, by diſtillation; very ſoluble in water, with which it unites in all proportions; forming either

a thick liquid filled with white, and as it were ſilky filaments, when this ſolution is ſtrong and concentrated, or an almoſt tranſparent liquid, when the water contains but little of it; giving to this liquid, beſides a ſoft, and as it were greaſy feel, an acrid urinous taſte, a milky ſemi-tranſparency, the property of forming much lather, and affording a kind of foam, which eaſily retains the air, and the gaſes under thin and tenacious tegument, as is exemplified in the ſimple art of making what are called ſoap bubbles; decompoſable by the acids, which ſeparate from it the oil, thick and more or leſs approaching to the ſtate of tallow or wax. We ſee by all theſe firſt phenomena that belong to ſoap, that in the union of the oils with the alkalis by which it is formed, the fixed oil has abſorbed a more or leſs conſiderable portion of oxigen; and that it is on this account that the contact of the air influences the ſaponification; that ſoaps are made more quickly and of better quality with the moſt concreſcible oils, or thoſe which are moſt diſpoſed to concrete, or even with thoſe that have already become concrete, eſpecially with the fats, &c. that it is alſo by this more ſpeedy oxidation, favoured by the preſence of the alkalis, that the ſoaps become ſolid, and that concrete oil is ſeparated from them by the action of the acids, and even of fire.

24. True ſoap, or that prepared with ſoda, is alſo diſtinguiſhed by the property of being decompoſed by means of barites, ſtrontian,

and lime. Its ſolution in water, mixed with that of theſe baſes, ſuddenly forms a precipitate in white inſoluble flakes, which when chemically examined, is found to be a compound of the concrete oil with the baſe employed. All the ſoluble ſalts of theſe ſame baſes, as alſo thoſe of magneſia, of glucine, of alumine, and of zircon, produce an inſoluble precipitate analogous to ſoap, in the ſolution of ſoap of ſoda. This is the reaſon why this ſaponaceous compound cannot diſſolve, but, on the contrary, aſſumes the form of curd, with waters charged with any earthy ſalts. A ſimilar phenomenon takes place with all the metallic ſolutions and ſalts. As ſoon as we pour theſe ſolutions into that of ſoap, precipitates are formed, which are compounds of the metallic oxides with the oil; theſe precipitates have different colours, according to the different oxides; their coloration is conſtant and fixed, according to Citizen Berthollet, who, in giving an account of theſe compounds under the appellation of *metallic ſoaps*, has propoſed them to be uſed in painting.

25. Ammonia alſo reduces the fixed oils to the ſaponaceous ſtate; but its more feeble attraction never brings them to the concrete ſtate, or favours their oxidation, as is done by the fixed alkalis: accordingly it never forms any thing more than ſaponaceous liquids, more or leſs opaque, though ſoluble in water, and capable of forming a lather, as alſo of taking out oily ſpots like the ſolid ſoaps. For the reſt, the ammoniacal ſoaps exhibit moſt of the properties of the ordinary ſoaps.

26. No ſalt acts in the cold, and really unites with the fixed oils. The ſulphates, with the aid of fire and a red heat, are decompoſed by the oils then reduced to the ſtate of hidrogen and carbon. The nitrates burn and decompoſe them at an elevated temperature. The muriate of ſoda is frequently employed for hardening ſoaps. The ſuper-oxigenated muriate of pot-aſh, triturated with a little fixed oil, and violently ſtruck, ſuddenly inflames and detonates.

27. Some metallic ſalts mixed with the oils are decompoſed and precipitated by theſe ſubſtances, which ſeparate and diſ-oxidate their metallic baſes. This is particularly obſerved to take place in the mixtures which are made for ſeveral emplaſtic compoſitions. But this effect has hitherto been but little examined, though it merits the attention of chemiſts.

28. The fixed oils unite artificially with mucilages and ſugar; by triturating them with theſe ſubſtances we render them white, opaque and more or leſs miſcible with water: this operation is frequently performed in the laboratories of pharmacy.

E. *Species.*

29. I HAVE already ſhown that the ſpecies of the fixed oils might be diſtinguiſhed by the aid of their chemical properties. I ought to add, that this method of diſtinction is ſo much the more eſſential and neceſſary, as the number of theſe vegetable productions is extremely conſiderable. Every country, every climate, according to the

differences of the vegetables which are cultivated in them, has different oils appropriated to a multitude of domeſtic and economical uſes. It would even be ſuperfluous here to preſent the enumeration of all the different ſpecies of oils that are extracted and employed in different places I ſhall therefore confine the enumeration which I propoſe to give, to the principal ſpecies known and employed, eſpecially in Europe, and particularly in my own country.

30. I ſhall here more particularly diſtinguiſh the fixed oils in common uſe into two genera. The firſt ſhall comprehend the *fat oils,* which have the character of becoming fixed more or leſs ſpeedily by the action of the cold, of thickening but very ſlowly in the air, and of being converted by it into tallow or wax. Theſe oils have alſo the property of being leſs alterable by the acids than the others, of eaſily forming ſoaps with the fixed alkalis, of being inflamed only by the nitric and the ſulphuric acids combined, and of becoming more or leſs ſpeedily rancid when kept in hot and moiſt places, in contact with the air. It is eſpecially in theſe fat oils of the firſt genus, that we find the mild principle of Scheele in the greateſt abundance. This chemiſt diſcovered that by combining the oil of ſweet almonds, of olives, and of rapeſeed with the oxide of lead, by the aſſiſtance of heat, and adding a little water to the mixtures, there was ſeparated from theſe oils a ſupernatant liquid, which furniſhed him, by evaporation, a

matter of the conſiſtence of a ſyrup, which took fire by being ſtrongly heated, of which one part was volatilized without burning in diſtillation, which afforded a light coal, which did not cryſtallize, and did not appear to be ſuſceptible of fermentation. The nitric acid, diſtilled four times upon this mild principle, changed it into oxalic acid. Theſe characters remarkably approach this ſubſtance to the mucilages, as I have already indicated, and I refer it to the mucous principle.

31. In this firſt genus of fixed and fat oils, I rank, eſpecially, the oil of olives, the oil of ſweet almonds, the oil of rape-ſeeds, or colza, and the oil of ben, the four ſpecies which are the beſt known and the moſt employed in France.

A. The oil of *olives* is the only known ſpecies that is extracted from the pulp of a fruit exterior to the kernel, or a ſpecies of huſk. The olive is bruiſed by a mill-ſtone placed vertically and turning upon an horizontal plane; the paſte produced by this operation is ſubjected to the action of a preſs which cauſes the virgin oil to run out of a greeniſh colour, and with a ſtrong taſte of the fruit. The marc or pulp is afterwards moiſtened with boiling water, and preſſed anew, in order to obtain the ordinary oil. The unripe olive yields a bitter oil, and that which is too ripe yields a paſty one. If the mills are not kept very clean, they remain impregnated with a rancid oil, which gives bad qualities to that which is afterwards fabricated in them. Olives that have been kept heaped together too long, and that have fermented, yield a ſtrong oil, which can be uſed only for making ſoap. The oil of olives congeals or cryſtallizes at 10 degrees below 0, and does not become rancid except after an expoſure, of ten years to the air. It is an aliment and condiment very much employed, and very uſeful in the Southern Departments of France.

B. The oil of *ſweet almonds* is extracted from almonds which are firſt violently ſhaken in a ſack of coarſe canvaſs, and roughly rubbed, in order to ſeparate from them the acrid powder which covers their epidermis. They are pounded in marble mortars; the paſte is afterwards ſubjected to the preſs, and the oil iſſues out a little greeniſh and turbid, and, like the oil of olives, depoſits a ſediment by repoſe.

C. Oil of *rape-ſeed*, and oil of colza, are the names given to thoſe which are extracted from the ſeeds of two ſpecies of cabbage, the firſt from the *braſſica napus*, and the ſecond from the *braſſica arvenſis*; this oil, which is very good, does not dry, is leſs fixable and leſs ranceſcent than the two preceding; it is much prepared in Flanders.

D. The oil of ben is extracted from the kernels of ben, which is very abundant in Egypt and Arabia; it is void of ſmell, but very ſuſceptible of rancidity, ſo that it very quickly becomes acrid; it eaſily congeals. As it is inodorous, it is particularly appropriated to perfumery.

We may ſubjoin to theſe four firſt ſpecies, the oil of beech-maſt, that of grape-ſtones, that of the ſeeds of the ſun-flower, and that of ſeveral ſpecies of cruciferous ſeeds, which are of a nature analogous to the preceding.

32. The ſecond genus of fixed oils includes thoſe which I call *drying*; their characters are that they dry in the air, at the ſame time preſerving their tranſparency, and without becoming a kind of tallow or wax. They do not become fixed, concreted, or cryſtallized by the cold, nor become rancid ſo eaſily as the preceding, nor do they form ſoaps ſo eaſily with the alkalis, nor inflame by the contact of the nitric acid ſurcharged with nitrous gas, without the addition of ſulphuric acid. They appear to contain leſs mucilage than the preceding: accordingly, the linſeed oil excepted, Scheele does not indicate them amongſt thoſe in which he ſays he has found the mild principle. It is alſo very probable that they owe their particular nature to another order and another proportion of combination in their primitive principles.

33. I alſo rank four principal ſpecies of fixed oils in the ſecond genus of oils deſignated by the epithet of *drying*: namely, oil of linſeed, oil of nuts, oil of poppies, and oil of hemp-ſeed.

A. The oil of linſeed is extracted, as I have ſaid, from the ſeeds of flax, either in the cold, and then with difficulty and in ſmall quantity; this is what is appropriated to medicinal uſes; or after having torrefied thoſe ſeeds in order to dry their mucilage, and facilitate the ſeparation of a larger quantity of oil: this, which is more or leſs roaſted, burned or reddiſh, has a taſte which indicates its origin, as well as the alteration which it has experienced. It is deſtined eſpecially for the arts, for painting, and for fat varniſhes. It has a very bad taſte; it burns ill, and thickens in the air, though ſlowly and with difficulty. In order to render it more drying it is boiled with a little oxide of lead or litharge, and it is then ſold by the name of boiled linſeed oil. It is in this ſtate that it is employed in the preparation of the fat lute of the chemiſts.

B. The oil of nuts is extracted from theſe kernels after a ſlight roaſting, or without the action of the fire. The latter, when prepared with care, is pretty good, and is uſed as food and condiment by a great number of the inhabitants of ſome of the Southern Departments of France. When it is extracted from old nuts, more or leſs rancid and roaſted, it has a very bad taſte, and can hardly be employed except for coarſe painting; it thickens and dries pretty quickly in the air.

C. The oil of poppies is ſeparated from the ſeeds of the poppy, which, on account of its beautiful flower, is called *oeillet* in the Northern departments of France, where it is cultivated in great abundance. This oil is very beautiful, very clear, conſiderably drying, without any diſagreeable ſmell or taſte, when it is well prepared. It is frequently employed as a condiment, and it is often ſold for oil of olives; the latter is even ſeldom ſold without an addition of oil of poppies: this oil has no ſoporific property.

D. The oil of hemp is expreſſed from the ſeeds of hemp; it has always a harſh diſagreeable taſte, and it is never uſed as a condiment. It is very drying and very thick: it is uſed only for ſome kinds of painting.

F. *Uſes.*

34. Fixed oil, in general, is a mild ſubſtance, and is uſed for nouriſhment, or for the ſeaſoning of food. Accordingly the ſeeds which contain it are the principal food of animals. It is uſed only as ſeaſoning to the aliments which man prepares, the form of which it varies in a ſingular manner; when alone it is not eaſy of digeſtion; accordingly it is ſcarce ever employed in this ſeparated ſtate, but mixed with different ſubſtances, and eſpecially with the vegetable acids.

35. In medicine the fixed oils are employed as emollients, relaxants, and, for allaying pains and irritations, diminiſhing the dryneſs of coughs, deſtroying the impreſſions of acrid matters and poiſons. Formerly much more uſe

was made of them than is now done. It has been diſcovered, ſince the middle of the eighteenth century, that oily ſubſtances are frequently more prejudicial than ſalutary to health, that they load the ſtomach, aggravate fever, increaſe the diſpoſition to putreſcence, and at preſent it is only ill-informed perſons who make a frequent uſe of them. They are generally adminiſtered with ſyrups; they are frequently preſcribed triturated with gums, ſugar and water, in the form of loches; they are employed in pharmacy in the preparation of a great number of chemical and pharmaceutical compound medicines, of ointments, plaſters, oily balſams, medicinal ſoaps, liniments, &c.

36. The oils are employed for a great number of uſes in the arts; they ſerve to preſerve many ſubſtances which are covered with them, or kept immerſed in them; for ſoftening leather, and ſkins; for preparing fat varniſh; for mixing the colours uſed in painting; for ſpreading on a number of bodies in order to render them ſmooth, ſoft, or flexible, and to defend them from the action of the water and the air; in the preparation of *maſtics*; for affording light by their combuſtion in lamps; for favouring the effect and the motion of metallic machines; in the manufacture of ſoaps, &c. &c.

ARTICLE XII.

Of the Ninth of the immediate Materials of Vegetables; of the Tallow and the Wax of Plants.

A. *Situation.*

1. I HAVE enumerated amongſt the characteriſtic properties of the fixed oils, their power of thickening in the air, and of thus forming, by the abſorption of oxigen, a ſebacious or waxy matter. This character ſhows itſelf in all caſes where the fixed oils iſſue from the plants, and are ſpread out in the atmoſphere. As it is then in ſmall drops, more or leſs minute, that theſe liquids exſude from the plants, being expoſed by this diſpoſition to the contact of the air, they attract oxigen more or leſs ſpeedily, and become concrete, ſo as to become a kind of tallow or wax.

2. It is in this manner that a waxy or ſebaceous matter is formed upon the catkins of the poplar, of the elder, of the pine, upon the leaves of roſemary, of ſage, on the ſurface of the fruit of the *myrica cerifera*, of the *croton ſebiferum*, and of a multitude of other ſeeds or vegetable capſules. But the moſt abundant, the moſt common, or rather the moſt general of theſe formations of concrete oily ſubſtance, more or leſs waxy, is that which takes place in moſt plants at the extremity of their ſtamens,

and on the external ſurface of the anthers with which they are terminated. This latter membranous organ, which has been compared with the teſticles of animals, preſents to the obſerver, at the moment of fecundation, a greeniſh or yellowiſh powder, granulated, fatty to the touch, which is very eaſily detached by the ſlighteſt motion or rubbing of the anthers. A great number of obſervations prove that it is of an oily or inflammable nature: the daughter of the celebrated Linnæus has even ſhown that, when reduced into vapour by the action of the ſun, this duſt of the antheræ, which however is not the real fecundating part, but only its reſervoir or vehicle, inflames at the approach of a combuſtible ſubſtance in the ſtate of ignition, and preſents the ſame phenomenon which is obſerved in the fraxinella.

3. Though Reaumur was not able to convert this powder into real wax by the different means which he has employed for this purpoſe; though the experiments which I myſelf have inſtituted upon the powder of the ſtamens of the male hemp, did not meet with the ſucceſs which I hoped, it cannot be doubted that it is from this pollen that the bees extract the ſubſtance with which they conſtruct their combs: after having collected and worked it into ſmall balls with the bruſhes with which Nature has furniſhed their paws, they carry it into the hive; they ſwallow it, reject it by the mouth, knead it with a humour that proceeds

from their bodies, give it the ſoftneſs and ductility which it muſt have in order that they may be able to work it in the conſtruction of their combs; and whether this change in the pollen be owing to the heat of the hives, or proceeds from the mixture of an animal humor with which they cover it, or finally whether it be the conſequence of a digeſtion, or any alteration produced by the action of their ſtomach, it is certain that the wax of the bees has no other origin than the pollen of the ſtamina of flowers, which it reſembles in many of its properties.

Sometimes the vegetable concrete oil, tallow or wax, is found in the internal part of fruits or ſeeds, and ſeems then to owe its formation and its nature to a combination of oxigen in the interior of the vegetable texture itſelf. It is in this manner that the parenchyma of the ſeed of the *croton ſebiferum*, and of ſeveral other vegetables, eſpecially the ſeeds of the caca, of the nutmeg, of the coco, contain a ſubſtance analogous to butter or tallow. I have obſerved that ſeveral of theſe ſeeds preſent at their external ſurface a more or leſs thick layer of real wax, well dried, concrete and brittle, whilſt their internal parenchyma is impregnated with a leſs concrete oil, or a kind of tallow, more fuſible, more ſoft, and much leſs reſembling wax, which proves that the contact of the air gives to the firſt a much more ſolid ſtate, a more marked oxigenation.

B. *Extrac-*

B. *Extraction.*

5. This kind of wax or tallow cannot be extracted from the vegetable matters which contain it in the ſame manner as is done with reſpect to the more or leſs fluid fixed oils. The ſolid ſtate of theſe bodies oppoſes it; we are obliged to expoſe them at firſt to a degree of heat ſufficient for ſoftening or melting theſe ſubſtances. At this temperature, which we communicate to the bruiſed ſeeds, or to the fruits that are covered with it, we may frequently, by afterwards ſubjecting them to the action of a preſs, cauſe this matter to run out. It is in this manner that it is extracted in pharmacy from the kernels of the cacao, ſlightly torrefied, reduced into paſte, and afterwards preſſed with more or leſs force.

6. A more commodious and ſurer means for obtaining this concrete oily ſubſtance is almoſt always employed. The ſeeds or the intire fruits that contain it in a thin layer applied over their external ſurface, are boiled. The heat of ebullition fuſes this concrete ſubſtance, and renders it very fluid; it then detaches itſelf from the integument to which it adhered, and collects in a liquid layer at the ſurface of the water. This is ſuffered to cool, and it is afterwards ſeparated very eaſily when it has become fixed in a ſolid plate at the ſurface of the water.

This proceſs is eſpecially employed for obtaining the wax of the galé, and ſometimes for collecting the butter of the cacao; it may be employed in general for all the vegetable matters at the ſurface of which this concrete oily juice is collected and thickened into a ſolid layer. When it is practiſed with the catkins of the poplar, the alder, the birch, the fir, ſmall quantities of a kind of wax or tallow are extracted.

7. In thoſe caſes where the vegetable fruits or grains contain, as is particularly exemplified in the *croton ſebiferum,* two kinds of concrete oily juices, the one more ſolid and of a waxy nature at the ſurface, the other ſofter and of a ſebaceous conſiſtence in the internal parenchyma; we may combine both the proceſſes that have been indicated in order to obtain each of theſe bodies ſeparate. We firſt boil them whole in water, which ſeparates the external wax; and when they are deprived of this they are bruiſed and expreſſed, after having heated them in order to extract from them the tallow. It appears that in China this two-fold practice is employed in order to obtain ſeparately the vegetable wax which is employed for making tapers for the opulent, and the tallow which is uſed for preparing a kind of candles deſtined for thoſe who cannot afford to purchaſe the others. I have performed this experiment upon the ſeeds of the croton, and have obtained two matters very well diſtinguiſhed by the ſoli-

dity and the concrete ſtate of the firſt, as well as by the ſoftneſs, the greaſineſs and the fuſibility of the ſecond. It was in this manner I diſcovered that this differs alſo from the firſt by a very marked purgative property.

C. *Phyſical Properties.*

8. THOUGH the concrete oils all reſemble each other in their conſiſtence, they have, however, neither the ſame texture nor the ſame ſolidity: ſome are mild, homogeneous, of a fine texture, and like butter as to their ſoftneſs and fuſibility; they are accordingly termed *vegetable butters,* as the butter of cacao, the queyamadoa, &c. others are of a granulated texture more or leſs cryſtalline, as the butter of coco, the tallow of croton. Laſtly, there are ſome of a firmer conſiſtence reſembling real wax, like that of the (galé,) the wax of the wax-tree of Louiſiana, &c. Some appear capable of aſſuming the lamellated form. The pollen of the ſtamens is in ſmall incoherent grains, and does not aſſume the concrete, ductile, dry, and uniformly ſolid ſtate of wax, till after it has been wrought by the bees.

9. The taſte, the ſmell, the colour, are alſo properties of this concrete oil that admit of much variation; it is ſometimes white, moſt frequently yellow or fawn colour, ſometimes brown or green, ſeldom red. Though the moſt of them

are inſipid, ſome are acrid, auſtere, or more or leſs pungent. Some are inodorous and others have a perfume. It is true that the latter moſt frequently owe this property to a portion of volatile oil which is more or leſs intimately and abundantly united with them, as we ſee in the butter of the nutmeg, and in all thoſe which proceed from aromatic fruits or ſeeds.

10. We alſo find the ſame variation in the fuſibility of theſe ſubſtances, from the extreme ſoftneſs of the butter of Galam, to the dry, brittle, and conſequently leſs fuſible ſtate of the wax of galé, and that of Louiſiana. This fuſibility commences between twenty-five and thirty degrees of Reaumur's thermometer, and extends to above ſixty, as we ſee in wax, properly ſo called, the pureſt and moſt valuable of theſe matters of vegetable origin.

D. *Chemical Properties.*

11. All the chemical properties of the butters and the waxes of plants, whilſt they approach more or leſs to thoſe of the fixed oils, preſent, however, differences which depend upon their concrete ſtate, and the proportion of oxigen which theſe oily juices contain. This difference ſhows itſelf at firſt, both in their diſtillations and in their combuſtion. When we diſtil them, we obtain water from them more eaſily; they yield more ſebacic acid; they afford an oil

ſufficiently thick and concreſcible, which is called *butter of wax*; we extract from them at laſt leſs hidrogen gas but more carbonic acid. The caſe is the ſame with their combuſtion; they do not require ſo much air in order to burn; they yield a whiter flame, leſs ſmoke and carbon; they burn more uniformly and more eaſily than the fixed oils. The uſe of candles and tapers evidently proves theſe firſt facts. When gently heated, this body becomes intirely volatilized.

12. Moſt of theſe concrete oily bodies which are coloured loſe this colour by degrees, which is deſtroyed by the contact of the air and of the atmoſpheric water. When they are expoſed in ſmall fragments or thin ſlips to the contact of the air, they loſe their colour and become white; this is what happens with wax when bleached, by leaving it upon the meadows and wetting it with water, whilſt at the ſame time it is expoſed to the rays of the ſun. This colouring part has been compared with that of ſilk.

13. Some combuſtible bodies unite ſtill more eaſily with theſe ſebaceous and waxy matters, and frequently experience more alteration from them than from the fixed oils properly ſo called. Sulphur and phoſphorus unite with them by fuſion. The metals that are eaſily oxidable are burned by them more or leſs quickly. Citizen Berthollet has found that by melting wax upon copper filings, and ſuffering it to remain upon

them for ſome time, this metal was much more ſpeedily converted by it into green oxide than it is by oil; and it is very evident that this effect depends upon the oxigen fixed in the wax.

14. It is for the ſame reaſon that the powerful acids exert ſcarce any action upon the concrete oils: as the fixed oils are altered by them only in conſequence of their attraction for oxigen; the oily juices that are ſaturated with it have no longer the ſame cauſe of alterability; accordingly we meet with much greater difficulty in attempting their analyſis by theſe burning bodies. The oxigenated muriatic acid which thickens the fixed oils, produces no ſuch effect upon theſe concrete oily juices, and only whitens thoſe whoſe colouring part is ſuſceptible of deſtruction by oxigen. It is in this manner that the green wax of Louiſiana is very quickly whitened by being merely immerſed and remaining for ſome hours in this acid.

15. The facility with which the alkalis unite with the tallows, the butters and the waxes of vegetables, confirms what I have ſaid above concerning ſaponification. It is evident that it is to the oxigenated ſtate of theſe concrete matters that they owe the property which they poſſeſs of combining and forming ſoaps with the cauſtic alkalis. The ſoap of wax and ſoda is termed *punic wax*, and is frequently employed as an encauſtic. Theſe combinations poſſeſs, beſides, all

the properties of the beſt ſoaps, and may be employed with much ſucceſs for the ſame uſes. As ammonia renders the waxes likewiſe ſoluble and ſaponaceous; its volatility may hereafter prove of uſe in the arts, in which it ſhould be an object to apply wax in a thin layer.

16. All the chemical properties of theſe bodies prove, therefore, that they are a kind of oxides of fixed oils, and that they owe their origin to a fixation of oxigen in theſe oils, to a combination without combuſtion, between carbon, hidrogen, and oxigen. There is reaſon to believe, that the chemical art will at ſome future period be able to imitate ſuch a combination, by fixing oxigen in the fixed oils, by means of different proceſſes and thus conſiderably augmenting their value by their converſion into artificial tallows or waxes. The firſt trials that have been made in this kind of reſearch already afford the beſt hopes, and they only require to be followed with more perſeverance.

E. *Species.*

17. UNDOUBTEDLY we are as yet far from knowing all the concrete fixed oily ſubſtances, which the vegetables are capable of furniſhing; their number is certainly much more conſiderable than has been ſuppoſed; and if we would, or could depend upon the vague, uncertain, and frequently ſo little enlightened accounts of

travellers, it would be poſſible to preſent a pretty conſiderable liſt of them. But as it is impoſſible to eſtabliſh any thing exact upon the ſimple aſſertions of moſt of theſe men, who are too little inſtructed to have been able to give exact notions concerning all the products of which they ſpeak, I ſhall here content myſelf with indicating the principal and the beſt known ſpecies of this genus, amongſt thoſe which I have been able to ſubject to ſome experiments, or which able chemiſts have indicated.

18. In this view I ſhall here cite the twelve following ſpecies: the butters of cacao, of coco, of nutmeg, of Galam; the vegetable tallow called queyamadou, that of the *croton ſebiferum*, the wax of the galé, the pela of the Chineſe, the wax of Louiſiana, the wax of the catkins, of the birch, of the alder, and of the poplar, the leaves of roſemary and ſage; finally the pollen of the anthers, and wax, properly ſo called.

A. The butter of cacao is extracted from the paſte of the ſeeds of this plant, *theobroma cacao,* either by ſubjecting it to the preſs, after having expoſed it to the vapour of boiling water, or by boiling it in water. More than a third and even nearly half the quantity of this paſte is extracted from it, when the cacao is ſound and of good quality. At firſt it is a little fawn-coloured or yellowiſh; it is purified by melting it again in water. It is then white, of a mild taſte, ſlightly granulated in its fracture, very unctuous to the feel, fuſible between twenty-eight and thirty-five of Reaumur's ſcale. It is this concrete oil that gives to chocolate its mild and unctuous taſte; it is ſometimes the cauſe of the difficulty which certain ſtomachs experience in digeſting chocolate; it is much employed in pharmacy.

B. The *butter of coco,* is found in the fruit of the palm, named *cocoſnucifera;* its heated pulp is expreſſed: ſome naturaliſts ſay, that it is ſeparated from the milk of coco in the form of cream; it is found congealed and granulated in the oils of coco that are frequently ſent to Europe. It is employed as a condiment in countries where the palm abounds.

C. The *butter of nutmegs* is extracted from this ſeed, *myriſtica officinalis,* bruiſed, ſoftened with water, and ſubjected to the action of the preſs; it is ſufficiently ſolid, of an orange yellow colour, of a pleaſant and aromatic odour, which it owes to the portion of volatile oil that is combined with it. It has an acrid and ſtrong taſte, which is much diminiſhed by keeping it fuſed, by agitating it in a large quantity of water, and by heating it for ſome time.

D. There is brought from Senegal, and comes by the way of the commerce of the interior of Africa, an oily, concrete, ſoft and very fuſible juice, which is called *butter of Galam,* from the African town where it is taken in the way of exchange; it is yellowiſh, almoſt always rancid, and acrid. It is ſaid to be employed as a condiment in the country. The tree, or the plant, which furniſhes it is not known.

E. The *Queyamadoa* is another ſpecies of concrete butyriform juice, which comes from Cayenne and Guiana: the tree whoſe fruit affords this butter, is called *virola ſebifera*, by Aublet; it is a myriſtica. This kind of butter is ſaid to be employed both as condiment, and as a combuſtible ſubſtance, in the country.

F. The *croton ſebiferum*, or *ſapium ceriferum* of Brown, Jacquin, and Juſſieu, produces in America, and in many other hot countries, fruits nearly round, the external tegument of which is covered with a layer of waxy matter, which is fuſed with the aid of boiling water, and collects at the ſurface of this liquid, where it becomes fixed by cooling. I have already obſerved that we may extract from the bruiſed kernel another matter which is leſs hard and leſs dry, more fuſible, more analogous to butter. Its ſmell, which is ſufficiently agreeable, induced ſome young perſons who performed this experiment in my laboratory, to try it as a condiment with ſpinach; it gave them all a more or leſs violent purging, attended with ſtrong colic pains. It ſeems this depends upon the periſperma, which is always acrid and purgative in this family of plants.

G. The wax of the galé is extracted in abundance in China, and in many of the Eaſtern countries, from the ſeeds of the *myrica cerifera*, and from one or two other ſpecies of myrica, called wax-trees. Its ſeeds, which are round, and of a bulk nearly ſimilar to that of the ſmalleſt coriander-ſeeds, are covered with a layer of white wax, which eaſily ſeparates from them by the action of boiling water, and ſwims upon the ſurface of this liquid where it becomes fixed by cooling. Fine tapers are made of it. We are alſo aſſured that after having extracted this external wax, which is very dry and very ſimilar to bees wax, the Chineſe obtain from the bruiſed ſeeds reduced into a paſte, another fat matter, more ſoft, more reſembling tallow, and which they employ in the fabrication of a kind of candles, which are cheaper than the tapers of the wax of the *galé.* Abundance of wax is extracted in North America from the ſame *myrica cerifera.*

H. There is known in China, by the name of *pela*, another kind of ceriform juice, ſolid, concrete, even brittle, of a very beautiful and very fine grain, with which the Chineſe fabricate the moſt highly eſteemed wax-works. We have hitherto no accurate knowledge concerning its origin. According to the report of the miſſionaries, we ſhould be led to believe that it is a wax wrought upon a tree by the inſects; but they add, that the ſpecies of worm which prepares it, contains it in its interior, and that it is extracted from the worm itſelf. Others ſay, that they are kinds of ſmall combs formed by the inſects upon the leaves of the tree, which are wrought in order to extract the pela from them. Nothing poſitive is yet known concerning this ſubject.

I. We ought to be better acquainted with the valuable and important matter which is called *wax of Louiſiana*, (*myrtle wax*) and which in fact affords a wax as fine as bees-wax, the properties of which it would be very uſeful to ſtudy, and to increaſe its importation into France. This ſpecies of green, granulated, brittle, dry wax is extracted from the ſeeds of a tree which appears to be the ſame with the myrica cerifera, or a proximate ſpecies, but with reſpect to which there is ſtill much uncertainty. Neither is it known in what manner it is extracted, though it is very probable that it is by boiling in water. It is imported into Europe in large cakes of the weight of ſeveral kilogrammes, of a greyiſh or yellowiſh colour. I have ſeen it of four different caſts. It is bleached very quickly by expoſure to the air and dew; the oxigenated muriatic alſo quickly deprives it of its colour, and bleaches it completely. By fuſing it afterwards, we obtain a ſpecies of wax almoſt as fine as bees wax, and which may be employed for the ſame purpoſes. It is ſaid that the green colour proceeds from the copper which is added to it, or from the copper veſſels in which this wax is melted. There is reaſon to believe that the myrica cerifera might be naturalized in the ſouthern departments. The myrica galé of the country about Paris affords no wax: it is from its name that the appellation of *galé*, or *piment* has been given to that of the Chineſe.

K. The male catkin of the birch, of the alder, of the poplar, and of the pine, yield, according to ſeveral authors, by boiling them in water, a kind of whitiſh wax, ſufficiently ſolid, in very ſmall quantity, and which has not yet been employed for any uſe, on account of its ſcarcity. No exact experiments have been made, and nothing poſitive is known reſpecting the properties of this oily juice, which perhaps is nothing more than a reſin. I ſhall apply the ſame obſervation to the pretended wax, which is ſaid to exſude from the leaves of roſemary, of ſage, and of ſeveral other labiated plants: if it had the relations, which it is ſuppoſed to have with that of the myrica cerifera, it is ſcarcely poſſible to conceive how ſo remarkable a fact ſhould hitherto have eſcaped the very multiplied inveſtigations that have been made reſpecting theſe plants.

L. I have already announced that the pollen of the anthers is a ſpecies of waxy matter not adhering, nor ductile, which ſeems to want a ſlight change in order to become real wax, a change which is produced in it by the ſtomach of the bees. It has not yet been practicable to convert the pollen of the anthers into real wax by chemical proceſſes; but experiments have not been ſufficiently proſecuted for this purpoſe, and every fact announces that by continuing our reſearches on this ſubject, we ſhall obtain all the ſucceſs that can be wiſhed. It is known that the powder of the lycopodium, which has been erroneouſly conſidered as a reſin, is very inflammable, and kindles by the mere contact of a body in the ſtate of ignition. This powder appears to be exactly of the ſame nature as the fecundating pollen.

18. Wax, in ſome meaſure the laſt product of the concrete vegetable oils, the moſt ſolid, the moſt brittle, the drieſt, and the leaſt fuſible of theſe concrete inflammable bodies, the moſt oxigenated of all the oily oxides, is collected in the hives, in the interior of which the bees have depoſited it for conſtructing their cells, of a colour at firſt fawn or yellow, but is deprived of its colour, and bleached by expoſure to the air, after it has been melted into thin layers, and known in this ſtate by the name of virgin wax; it is the moſt employed, and moſt uſeful of theſe combuſtible ſubſtances. Its ſoftneſs, its ductility, its fuſibility, its looſe texture, its whiteneſs, even its preſervation, its brilliant combuſtion, its dryneſs, its purity, and inodorous quality render it of ineſtimable value for the purpoſes of life. We ſhall ſpeak of this ſubject in the ſubſequent ſection.

F. *Uſes.*

19. The numerous uſes in which theſe butters, tallows and waxes of plants are employed, are ſufficiently known. I have already

elſewhere indicated a part of them, in the enumeration of the ſpecies: as condiments, as mild aliments, as matters proper for lubricating the ſurfaces of a great number of bodies, as combuſtibles proper for diffuſing a beautiful light, and diſpelling the obſcurity of long nights, theſe precious vegetable products render many ſervices to man. They are alſo employed for forming the ſolid maſs of ſtatues, for pouring into moulds, and repreſenting in relief all the objects whoſe image we wiſh to preſerve, or to imitate their forms. The ſculptor, the ſtatuary, and the model-maker find in them materials upon which they can exerciſe their talents. There are, therefore, few bodies more generally employed; and accordingly all countries have their wax, or their particular vegetable butters, and all nations are careful not to neglect, or deſtroy the plants which furniſh them.

20. Medicine has alſo derived very important advantages from them. The wax and the butter of cocoa anſwer a great number of purpoſes, and are applied to a ſeries of pharmaceutical works and preparations. Sometimes they are employed as recipients, to baſes of other medicines; ſometimes they ſerve to give conſiſtence to remedies more or leſs compounded, ſuch as ointments and plaſters. Their mild or inſipid taſte, their unctuous and relaxing quality, and their emollient property, cauſe them alſo to be employed as primary and eſſen-

tial remedies in a great number of caſes in which theſe virtues are indicated.

ARTICLE XIII.

Of the Tenth of the immediate Materials of Vegetables; of the Volatile Oil.

A. *Situation.*

1. THE name of *volatile oil*, in very marked oppoſition to the former, is given to that oily juice, which when heated, like the fixed oil, riſes more or leſs ſpeedily and eaſily in vapour. It was formerly called *eſſence*, and *eſſential oil*, becauſe it was conſidered as really determining the exiſtence of the eſſence of the vegetable matters which furniſh it. Beſides the characters of volatility, which diſtinguiſh it from the fixed oils, it has alſo a ſmell more or leſs fragrant and aromatic; it is on account of this property that it was deſignated by the names of *eſſence* and *eſſential oil.*

2. It is not with this genus of oils as with the preceding; they are not conſtantly diſtributed and inſulated in the ſeeds or the fruits of the vegetables. Experience ſhows that all the parts of vegetables are capable of contain-

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ing them, and that by a very remarkable contraſt with the fixed oils, they are never met with in the interior of the ſeeds themſelves. This latter fact, which has not ſufficiently fixed the attention of chemiſts and naturaliſts, proves that the properties of theſe oils are intirely oppoſite to thoſe of the fixed oils, and that their uſes in nature and in the vegetable economy are altogether different; their burning acrimony would render them no leſs prejudicial to the embryos and the plantulæ, than the unctuous and nutritive mildneſs of the firſt renders them uſeful to theſe delicate beings. Nature has taken the ſame care to remove the volatile oils from the interior parts of the ſeeds, as ſhe has to convey the fixed oils thither; the latter are a real milk to the young plants; the former would act upon them as a deſtructive poiſon.

3. There are a multitude of odorous, aromatic roots, more or leſs acrid in their taſte, which contain volatile oil, but in ſuch ſmall cells, or in ſuch minute veſſels, that the eye cannot diſcern it in them, and that it cannot be extracted by mechanical means; but the ſmell, the inflammable property, and the more or leſs hot and burning taſte of theſe woody roots prove them to contain this vegetable principle. The principal examples of roots charged with volatile oil, are the avens or bennet, elecampane, white dittany, Florentine orris-root, &c.

4. A great number of woods, eſpecially the *ſantal*, very improperly called *ſandal*-wood in

commerce, and in the arts, the lignum Rhodium or roſe-wood, the pines, the firs, the larches, and moſt trees of the hot climates, eſpecially in India and America, contain more or leſs conſiderable quantities of volatile oil, which is intimately and profoundly contained in them. The aromatic and pungent barks are alſo impregnated with them, eſpecially thoſe of cinnamon, of the caſſia lignea, &c.

5. The leaves of all the labiated plants are filled with volatile oil, and frequently even the cellules which contain it are viſible or perceptible to the naked eye by the rugoſities, the aſperites, the tubercles which mark the ſurface. There are even ſome, like thoſe called (in French) on that account *mille-pertuis*, that preſent to the eye very numerous tranſparent points, which have been taken for holes, but are merely ſmall cellules, covered only by the epidermis. All theſe oily leaves are diſtinguiſhable by their lively odour, which is particularly developed when we bruiſe them in the hands, and by the manner in which the vegetables which bear them quickly change the air of the atmoſphere. Amongſt the ſpecies of plants with odoriferous leaves, are eſpecially enumerated balm, the mints, eſpecially pepper-mint, phlomis, origanum, roſemary, and many other labiated plants. The odorous leaves of the umbelliferous plants, and eſpecially of parſley, chervil, fennel, and angelica, alſo afford volatile oil. For the reſt the chemical character of

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this family is to contain volatile oil in every part. The leaves of the compoſite plants, ſuch eſpecially as wormwood, and camomile, afford much of it; hypericum and rue are of the ſame claſs.

6. There are fewer flowers capable of furniſhing it. We may however diſtinguiſh the florets, and ſemi-florets of the camomile, as well as of ſeveral ſyngeneſian plants, the petals of the lemon and orange trees, in which it is ſeen in tranſparent cavities. Many flowers contain it in their calixes, ſuch as the roſe, the clove, lavender, thyme, and a great number of labiated plants; ſometimes even we can obſerve the veſicles that ſerve as reſervoirs for it, like ſmall tubercles, or ridges, or parts more tranſparent than the reſt. In general we obſerve that the oleiferous perianthuſes are either fleſhy like thoſe of the roſe, or ſquarroſe and ligneous, like thoſe of the labiated plants.

7. Volatile oil is ſometimes fixed in the fruits, and eſpecially in their teguments. Vanilla, cardamoms, cubebs, pepper, the berries of the juniper, are of the firſt order. Lemons, oranges, citrons, bergamots, and all the fruits of the genus *citrus*, contain it in their external coloured ſkin, and in ſmall cells, excavated in their zeſt, which are eaſily perceived on the outſide of theſe fruits, and which appear in the form of ſmall cavities diſperſed over its ſurface: here the quantity of this oil is ſufficiently conſiderable, and the reſervoirs

which contain it are ſufficiently full for it to be extracted by ſimple preſſure, as is proved even by the play of children when they ſqueeze orange-peel cloſe to the flame of the candle, in which the volatile oil affords a flaſh of fire and very white ſparks, as it paſſes through it.

8. Laſtly, there are a multitude of ſeeds from which the volatile oil is extracted in conſiderable abundance; but it is not contained in their interior, as I have already remarked; Nature has even taken many precautions in order to remove it from the embryo lodged between the cotyledons. On the outſide of theſe there is a tunic, frequently horn-like, ſometimes double, in the duplicature of which the particles of volatile oil are lodged; ſo that being ſituated on the outſide of this hard and impenetrable integument, it cannot paſs through and reach the interior part. This admirable ſtructure is eſpecially obſerved in the ſeeds of a great number of the umbelliferous plants, whoſe ridgy furrowed, tuberculated ſurface is placed beneath theſe appendages of ſmall drops of volatile oil. What has been ſaid of the nutmeg, which contains volatile oil in its interior ſubſtance, muſt be underſtood only of a particular ſubſtance which is not the pulp of the cotyledons itſelf, but a kind of periſperma, which has no communication with the embryo.

9. The quantity of volatile oil varies greatly in the parts of vegetables that contain it, according to the age and the ſoils which have produced them. Some plants yield more of this

oil when they are freſh; others, which are fewer in number, afford more of it when they are dry. We may ſee in the Elements of Pharmacy of Baumé, an uſeful notice concerning the preparations of this matter extracted from the principal plants in common uſe, in different ſtates and in different years.

B. *Extraction.*

10. There are two general proceſſes for obtaining volatile oil. When this principle is ſufficiently abundant, fluid, and contained in veſicles, almoſt inſulated and pure, ſo as to be capable of being ſeparated from them by mechanical means, ſimple expreſſion is then employed. It is in this manner that the volatile oil is extracted from the lemon, the citron, the bergamot and the orange; it is well known that by preſſing the freſh peels of theſe fruits we cauſe this oil to ſhoot out in the liquid form. In the ſouthern departments of France, and in Italy, theſe freſh peels are raſped, the oily cells are lacerated, the paſte formed by the parenchyma impregnated with oil is preſſed upon inclined plates of glaſs, the oil collects upon them in drops which unite, and run towards the bottom where they are collected; they are ſuffered to depoſit a fine ſediment by being kept at reſt in cloſe veſſels, and thus are obtained what perfumers call eſſences extracted without heat.

11. Moſt of the oleophorous plants do not admit of this treatment, becauſe they do not

contain the volatile oil ſo detached, ſo diſtributed, ſo fluid, and ſo abundant: all theſe and their parts which are dry are treated by diſtillation. After they have been macerated for ſome hours in water; they are put with the water into a copper alembic, which is filled about two thirds; a capital of tin provided with a refrigeratory is added, and luted with ſized paper to the cucurbit. The fire is urged to ebullition, after cold water has been put into the refrigeratory; a large quantity of the vapour of odorous water riſes charged with volatile oil, which it actually contains in ſolution, and accompanied with the portion of volatile oil which it cannot diſſolve on account of its abundance; both theſe products are received into a veſſel of glaſs of a particular form, which is called a Florentine receiver, becauſe it was firſt uſed at Florence. It is a conical veſſel having a tube a little above its bottom, the upper extremity of which reaches only a little below the aperture of the receiver, and which, being curved at this place towards the baſe, ſuffers the more abundant portion of water to run off, and permits the oil to collect in the upper part of the receiver; formerly a worm was employed in the diſtillation of the volatile oils; but it has been laid aſide, becauſe it was perceived that a portion was loſt, which attached itſelf to the ſides of the metallic tube.

12. The water which paſſes with the oil is white, turbid, and as it were milky, becauſe it contains a ſmall quantity of oil ſuſpended; but

this liquor gradually clarifies, by depoſiting this oil, which riſes to its ſurface and unites with that which paſſes immediately in drops. When this water has become clear, it is ſtill charged with the odour of the plant, and it was formerly thought to be impregnated with a particular principle of the vegetable which Boerhaave called *Spiritus Rector*, and was deſignated by the name of *Aroma* in the methodical nomenclature; concerning the pretended exiſtence of which I ſhall ſhow that the chemiſts have committed a great error. This odorous water, which accompanies the volatile oil in its diſtillation, is nothing but a real ſolution of volatile oil in the water as I ſhall ſoon demonſtrate. As a firſt proof I here mention the property which it has long been admitted to poſſeſs, of augmenting the quantity of oil that can be obtained by the diſtillation of a plant, when we diſtil it dry and ſcarcely odorous, with the aromatic water obtained from the ſame plant: this is always carefully practiſed in laboratories that are managed with proper care and attention.

13. Some different practices are followed in the diſtillation of the volatile oils, according to the dry, ſolid, or more or leſs hard nature, and according to the proportion of this principle which exiſts in the vegetable ſubſtance. The roots, the woods, the barks, the fruits, the dried plants, are macerated for a longer or ſhorter ſpace of time in water, after they have

been cut, chopped, raſped or pounded. This maceration continues from ſome hours to ſome days, according to the ſolidity or the dryneſs of the vegetable matter. In order to raiſe the mixture of water and plants to a higher temperature, and to cauſe a greater quantity of volatile oil to come over, chemiſts have recommended a certain doſe of muriate of ſoda to be added, which by giving greater denſity to the water, cauſes it to aſſume a higher temperature previous to its volatilization. The freſh plants in full vegetation are diſtilled with leſs water, and do not require to be previouſly macerated, nor do they demand ſo high a temperature in order to give out their volatile oil.

14. A proceſs was formerly employed in the laboratories of pharmacy and perfumery, which has long ſince been laid aſide on account of its imperfection and the bad product which it afforded. The vegetable matter, generally dry, eſpecially the clove, was bruiſed and placed upon a piece of linen extended over the ſurface of a conical glaſs almoſt full of water; upon this linen and above the vegetable matter which it ſupported, a plate of copper containing ignited coals was placed; the caloric diſengaged from theſe coals penetrating the vegetable ſubſtance, fuſed and ſeparated the oil which paſſed through the linen, and fell into the glaſs, where it was collected at the ſurface of the water. This operation was termed *diſtillation per deſcenſum*, on account of the direction which the fire placed above gave to the vapour; but it afforded a

brown and partly burned oil, mixed with that which the ſtrongly torrefied vegetable matter yielded, and with coal; it had beſides the inconvenience of cauſing a loſs of the greater part of the volatile oil, which eſcaped between the linen and the bottom of the plate of copper.

15. As moſt of the volatile oils are intended for perfumery under the name of eſſences, and appropriated to the preparation of different fragrant matters, I muſt here ſubjoin a fourth proceſs which is not generally ranked in this order of chemical facts, becauſe it has been conſidered as belonging to the hiſtory of the aroma, the particular exiſtence of which I do not admit, for reaſons which I ſhall ſoon explain. There are ſome plants or flowers of an extremely pleaſant and agreeable odour, from which no volatile oil can be obtained by diſtillation, becauſe this principle is ſo delicate in them, ſo much attenuated, and ſo eaſy to be decompoſed, that the temperature requiſite for diſengaging it deſtroys it, alters it, and renders it fetid: ſuch are the tuberoſe, the narciſſus, the jonquil, the lily of the valley, the hyacinth and moſt of the ſo highly fragrant flowers of the liliaceous tribe. Such are alſo in other families of vegetables, the reſeda, the turnſole and ſome others. A method has been contrived for collecting, fixing, and diſſolving this very fugacious and decompoſable odorant principle, by incloſing theſe flowers in cotton impregnated with a fixed inodorous oil, and ſuffering them to macerate for ſome time at a mild temperature.

perature. The oil of ben is taken for this operation; alternate layers of cotton impregnated with it, and of flowers are placed over a water-bath; the laſt of the layers of flowers is covered with a thick layer of the oiled cotton; a tin lid is cloſed and well luted on; the veſſel is then plunged into a water-bath, the water of which is kept at thirty degrees of heat and upwards; here it is left for ſome hours, or even ſome days; it is then cooled, after which the layers of cotton are carefully taken out, and preſſed; the oil which flows out is charged with the odorous principle of the flowers, and forms a kind of artificial eſſence; and it is ſo true that it is to a volatile oil that this odour is owing, that by afterwards treating the perfumed oils with alcohol, we take from them all this odour, and in that manner prepare what were formerly termed ſpirituous eſſential waters, or ſpirituous aromatic waters.

C. *Phyſical Properties.*

16. Though volatile oil, to whatever plant it may belong, and however varied it may be in its properties, nevertheleſs always preſents ſome that are ſufficiently diſtinct and ſufficiently marked to be capable of being conſidered as characteriſtic of this genus of immediate materials; though we may particularly enumerate in this order their fragrance and their volatility, yet theſe properties have ſuch a number of differences that it is impoſſible to

deſcribe them in a general manner, and it becomes indiſpenſably neceſſary to take a ſurvey of the principal varieties which they preſent, in order to obtain a competent notion of the whole genus.

17. I ſhall begin with their odour. The utmoſt ſtretch of the imagination cannot comprehend the aſtoniſhing multiplicity of varieties and of differences that belong to this firſt character. Not only each plant and every oil has its peculiar character, but it alſo varies in each of theſe products, by ſhades which the organ of ſmell can alone appreciate, according to a multitude of circumſtances, the influence of which it is impoſſible to point out though we can eaſily recognize their exiſtence. What is of the greateſt importance to be well known in this reſpect, is that there does not exiſt, as has hitherto been believed a particular principle independent of the oil itſelf, which was formerly conſidered as the aroma or Spiritus Rector, which was ſaid to be diſengaged from the volatile oil: it is the volatile oil intirely reduced into vapour, and acting in its totality upon the olfactory nerves.

18. The conſiſtence of volatile oils varies, but much leſs than their odour. There are four principal kinds of conſiſtence in theſe oils; ſome are fluid in appearance, like water or thoſe of lavender, of rue, of lemons, of bergamot, and of citron; this is eſpecially obſerved in the oils obtained by expreſſion. Some are thick, and viſcid, as are in general thoſe of the woods, the roots, the barks and the fruits of India and

America. Others congeal and aſſume a granulated or ſolid conſiſtence at temperatures more or leſs low, ſuch as thoſe of aniſeed, fennel, parſley, and balm; ſome of the latter are always concrete, like that of the roſe, which has the conſiſtence of a butter or fat. Laſtly, ſeveral are capable of cryſtallizing, and depoſiting in the midſt of the portion that has remained liquid, tranſparent polyhedra, more or leſs yellow, which are nothing elſe than pure oil; it appears, however, that this latter effect which takes place only in the courſe of time, and has been obſerved eſpecially in the oils of roſemary, and of lavender, depends upon a commencement of oxidation, as Citizen Vauquelin had ſuſpected. Sometimes theſe oily cryſtals have been confounded with camphor, which is eaſy to be diſtinguiſhed from them, as I intend to ſhow.

19. It muſt alſo be admitted that a great difference obtains in the colour of the volatile oils. There are ſome which are colourleſs or have only a ſlight lemon-colour, like that of aniſeed, and moſt of thoſe that are extracted without the action of fire from the ſkins of fruits. Moſt are of a more or leſs marked yellow, ſuch as that of the officinal lavender, that of the greater lavender, which is called oil of ſpike, *lavendula ſpica,* and a great number of others; ſome are of a deep yellow, red or brown colour, as the oils of cinnamon, of cloves, of Rhodium, &c.; ſeveral are blue, that of camomile, green, like that of parſley, of a greeniſh

blue, like that of hypericum; ſome are obtained blue at the moment of their diſtillation, but afterwards become red by lapſe of time, as is obſerved in the oil diſtilled from galbanum, &c. In general the yellowiſh and reddiſh are the two predominant colours in the volatile oils, and it is always at one or other of theſe tinges that they arrive and remain.

20. The taſte of the volatile oils is almoſt conſtantly acrid, pungent, hot, and even burning; ſome, however, have only a very feeble taſte. Frequently thoſe vegetable ſubſtances that are very acrid and bitter, do not yield an oil that has this property, as is the caſe with pepper and with worm-wood. When we place a ſingle drop of volatile oil upon the tongue, it produces upon it the ſenſation of a very violent burning and irritation. This ſenſation frequently even propagates and extends itſelf into the throat, the oeſophagus, and as far as the ſtomach, by an impreſſion of heat and acrimony, which excites with delicate and nervous perſons, ſpaſms, borborygmi, eructations, nauſea, weakneſs, and ſickneſs. Frequently this ſcene, which is entirely owing to the nervous action, terminates in evacuations. Accordingly the phyſicians, who rank this matter amongſt the almoſt cauſtic and acrid ſubſtances, when it acts in the maſs, have conſidered it, when preſcribed only in a very ſmall proportion, and extended in a voluminous vehicle, as a ſtimulant, and more or leſs powerfully irritating. Its effect is ſpeedily propagated to organs far remote from the place

to which the volatile oil is applied: in this manner it quickly imparts to the urine a ſtrong ſmell, which is frequently agreeable, and reſembles that of the iris or violets. It is by a ſimilar principle that aſparagus appears to communicate to it an inſupportable fetor.

21. In general, the volatile oil has a ſpecific gravity inferior to that of water, and as is well known, ſwims upon the ſurface of this liquid. However, thoſe of the clove, of cinnamon, and of ſaſſafras ſink in water; but it is not to be concluded from hence, that the oils of exotic plants, thoſe of India eſpecially, are generally heavier than water, ſince thoſe of mace, of nutmegs, of pepper, of cubebs, of cardamom, are lighter than this liquid. In general the ſpecific gravity of the volatile oils that are lighter than water is to that of this liquid as 8697, 8938, 9910 to 10000. That of thoſe which are heavier on the other hand, : : 10363 or 10439; 10000.

22. To this enunciation of characters, or phyſical properties, we muſt ſubjoin that of the adulterations or ſophiſtications which are too frequently practiſed upon theſe oils; it is almoſt always with the fixed inodorous oils or with oil of turpentine, the moſt common and the cheapeſt of theſe ſubſtances that the more coſtly volatile oils are diluted and their quantity increaſed. By rubbing a piece of fine paper which quickly becomes impregnated with it, we diſtinguiſh a volatile oil adulterated with a fixed oil, by the circumſtance that when the portion

of the firſt has been volatilized, there remains upon the paper an oily ſpot, formed by the fixed oil, which is not volatilized in the ſame manner. As to thoſe that are mixed with oil of turpentine, they are diſtinguiſhed by the very characteriſtic odour of the latter, which remains for ſome time after the volatilization of the other. Mere friction in the hands is frequently ſufficient to diſtinguiſh both theſe ſophiſtications by the ſmell. It is more difficult to diſtinguiſh the mixtures of the volatile oils that reſemble one another in their ſmell, conſiſtence and colour; but theſe are more rare and leſs fraudulent. When they are mixed with alcohol, we may eaſily diſcover this fraud by throwing them into water, which produces a very abundant milk-white precipitate.

D. *Chemical Properties.*

23. After what has been ſhown in the two preceding articles concerning the chemical properties of the fixed oils, it is only neceſſary to compare the volatile oils with the former, and to inſiſt upon the differences that ſubſiſt between theſe two genera of bodies. It is evident, that the firſt difference which characterizes them, and which is expreſſed by their name, is that they muſt be infinitely more difficult to be decompoſed by the action of the fire than the fixed oils. They are reduced ſo quickly, and ſo eaſily into vapour, that it is almoſt impoſſible to effect their decompoſition

in this manner. However by diſtilling them very ſlowly with a gentle heat, after having fixed them to a certain degree by means of very fine ſand or alumine, they afford water, carbonated hidrogen gas, carbonic acid gas, a portion of oil a little thickened, and they leave a coaly mark. By repeating this operation, the volatile oil is at length decompoſed, though very ſlowly, and with great difficulty.

24. They are much more combuſtible, they inflame in the cold by the mere contact of a body in ignition, or by the electric ſpark; they diffuſe, whilſt burning, an abundant ſmoke, and yield much ſoot; their flame is very ſtrong and very white; the heat which they diſengage very abundant, and they require more oxigen for their combuſtion than the fixed oils, and afford more water amongſt the products of their combuſtion. This manifeſtly proceeds from the large portion of hidrogen which they contain, and from the ſmaller quantity of their carbon. On account of their greater combuſtibility, the oil of lavender, or ſpike, is uſed for the purpoſe of lighting lamps for illuminations with greater diſpatch, by firſt impregnating their wicks with this oil.

25. When expoſed to the cold air, they undergo another kind of alteration. Moſt of them become coloured and thickened, they all emit a ſtrong odour; they vitiate the air, and quickly render it deleterious to animals, as is proved by the paintings in which they are employed; they emit hidrogen which forms

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water, of which we frequently find drops more or leſs perceptible at their ſurface, when they are kept in veſſels not properly cloſed. Some of them cryſtallize; moſt of them paſs into the reſinous ſtate, and then loſe the greateſt part of their odour; which manifeſtly depends upon the joint effect of the loſs of a portion of their hidrogen, and the augmentation of their carbon.

26. They combine ſenſibly and eaſily with water. It is ſufficient to agitate them in this liquid, in order to diſſolve them. The fluid then contracts a ſtrong ſmell, and a ſlight acrid taſte; it is in this manner that I prepare the fragrant aromatic waters, which are nothing more than ſolutions of volatile oil in water, prepared by the action of fire, and diſtillation.

27. They diſſolve phoſphorous and ſulphur. The firſt of theſe ſolutions, which is luminous in the dark, is very fetid, and affords phoſphorated hidrogen gas by the action of fire, the ſecond, which is very much coloured, and known by the name of *balſam of ſulphur* in pharmacy, a name to which that of the oil with which it is prepared is added, as *terebinthinated*, *aniſated*, &c. affords much ſulphurated hidrogen gas by the action of heat. They do not act upon the metals, nor do they combine with their oxides like the fixed oils. In general they are leſs diſpoſed than theſe to form oily oxides, and when treated with oxigenated matter, whatever theſe matters may be, they tend

rather to be decompoſed, and to ſuffer their hidrogen and carbon to become inſulated.

28. This is the reaſon of the difference of the action which the acids exert upon the volatile oils, from that which they exert upon the fixed oils. In general the former are much more decompoſable and alterable by theſe bodies. The concentrated ſulphuric acid renders them brown and thick, by diſengaging part of their hidrogen with effervеſcence and heat; it converts a portion of them into water. What remains of the volatile oil after this action, is neither a reſin, nor a bitumen, as has been believed; it is really the volatile oil reduced to coal, in part decompoſed, and containing an acid. The nitric acid, charged with nitrous gas, inflames them immediately, converts a large part of them into water and carbonic acid, but leaves a voluminous and light coal; the ſame acids, diluted with water, turn theſe oils white or yellow, and thicken them, but do not reduce them to the real ſaponaceous ſtate, as has been pretended. This is only a ſlow decompoſition, which tends to convert them into vegetable acids. The muriatic acid alters them but very little. The oxigenated muriatic acid whitens them, renders them partly concrete, or thickens them, and brings them nearer than the preceding to the reſinous ſtate.

29. The alkalis do not diſſolve them but with much difficulty: hence the very long diſcuſſions amongſt the chemiſts concerning

the ſoap propoſed by the alchemiſt Starkey The ſmall quantity of ſoap obtained by triturating concentrated cauſtic alkaline leys, with the volatile oils, and leaving them for ſome time together, is termed *ſavonule* in the methodical nomenclature, in order to indicate, that it is in fact a combination very ſlightly, or very little ſapanaceous. This weak combination between theſe matters, evidently depends upon the little tendency which a volatile oil has to abſorb oxigen without being decompoſed by it, or to form an oily oxide.

30. The ſalts exert no ſenſible action upon the volatile oils. The nitrates burn them with the aſſiſtance of heat. The ſuper-oxigenated muriate of pot-aſh inflames, and deſtroys them by percuſſion. The metallic ſalts and ſolutions are frequently decompoſed by the volatile oils, eſpecially when they are left for a long time in contact with theſe mixed combuſtible bodies. Thus a ſolution of gold, agitated with a volatile oil, and kept for a long time with it, precipitates grains or plates of gold: the oil acquires, in this caſe, the property of ſeparating in the cryſtalline, ſolid, and regular form, as has been obſerved by Citizen Vauquelin.

31. Laſtly, volatile oil unites more or leſs eaſily with the different materials of vegetables that have already been examined. Mucilage, ſugar, and even fecula, with the aid of a little heat, render them either ſoluble or capable of remaining for a long time ſuſpended in water. It is in this manner that we may communicate to this liquid, or

to ſeveral other bodies, the aromatic part of fruits with volatile oil, ſuch as the citron, the orange, &c. the peel is rubbed with ſugar, which abſorbs a portion of oil; and afterwards diſſolve this ſugar in water: this is what is named *oleo*, or *oleoſaecharum.* The volatile oils are very eaſily united, either with the fixed oils by ſimple agitation and mere mixture, or with the waxes and vegetable butters, by means of a gentle heat. The latter fix them in ſome meaſure, and thus form the unguents, or the fragrant ointments of the ancients. Nature preſents, ready formed, this union of an oily and butyraceous juice with a volatile oil, in the butter of nutmegs and in ſeveral other vegetables.

E. *Species.*

32. All that has been ſaid concerning the principal differences of the volatile oils, eſpecially as to their ſituation, of their extraction, and of their phyſical properties, might in fact be ſufficient to obviate the neceſſity of diſtinguiſhing ſpecies in this vegetable principle, and even to eſtabliſh a ſufficiently marked diſtinction amongſt them. I ſhall, therefore, content myſelf with preſenting a conciſe ſketch of the method which may be followed in order to divide the volatile oils into ſpecies, at the ſame time remarking, that I cannot attend to the object of treating ſimply of the numerous ſeries

of oils, which are employed in the arts, but ſhall merely refer them in general to a certain number of principal ſpecies.

33. On comparing with each other the very numerous volatile oils, which are extracted from plants for the purpoſes of pharmacy or perfumery, I divide them into ſix principal genera, according to their ſenſible characters, their chemical properties, or their mixtures, and I deſignate theſe ſix genera by the denominations of *fugacious* oils, *light* oils, *viſcid* oils, *concrete* oils, *ceraceous* oils, and *camphorated* oils.

34. I term thoſe fugacious oils, which cannot be collected either by diſtillation, or by expreſſion; which cannot be obtained except by abſorbing them from the vegetables which contain them, and fixing them by means of fat oils. The principal ſpecies of this kind, which have hitherto been confounded with the ſpiritus rectors, or pretended aromas, are thoſe of the lily, of the tuberoſe; the narciſſus, of the hyacinth, of the convallaria, of the jaſmine, of the reſeda, and of the heliotrope.

35. The light oils of the ſecond genus are thoſe which are very liquid, almoſt colourleſs; extracted by the mere expreſſion of the cortices in which they are incloſed in very viſible veſicles. The beſt known ſpecies are the eſſences of lemon, of orange, of citron, of bergamot, &c. It is to be obſerved, that theſe are capable of paſſing into the two following ſtates, with the aſſiſtance of time and loſs of hidrogen.

36. In the third genus I place the viſcid or thick volatile oils, generally of a brown colour. The preceding, when kept for a long time, arrive at this ſtate. This genus comprehends the oils of mace, of cardamoms, of pepper, and eſpecially the oils that are heavier than water, of ſaſſafras, of cloves, and of cinnamon.

37. To the fourth genus I refer the volatile oils, obtained like the preceding, by the action of fire and diſtillation, but which aſſume a concrete or cryſtalline form, either by cooling, or by a ſlow evaporation and cryſtallization. The principal ſpecies of the firſt are, the oil of parſley, of fennel, of aniſeed, of balm, of roſe, to the ſecond belong the oil of thyme, of marjoram, of mint, and undoubtedly a much greater number ſuſceptible of cryſtallization.

38. The fifth genus is formed by the volatile waxy oils which nature preſents, and which art extracts by preſſure, and their previous ſoftening by means of fire, in the concrete ſtate, united with butyraceous, or waxy oily matters. Hitherto, we know only the oil of nutmegs of this genus, but there undoubtedly exiſt many others in nature.

39. Laſtly, I appropriate the ſixth genus of volatile oils to thoſe which I term camphorated, becauſe they naturally hold in ſolution the volatile and inflammable ſubſtance, which ſhall be examined in the ſubſequent article, under the name of camphor. The oils of roſemary, of ſage, of lavender, of matricaria, of marjoram,

of pulſatilla, of the roots of zedoary, of valerian, &c. belong eſpecially to this genus.

Theſe diſtinctions, however, will be rectified in proportion as the obſervations upon theſe oils ſhall become more exact and more numerous.

F. *Uſes.*

40. It has been ſeen, by all the preceding details, that the volatile oils are uſeful for a great number of purpoſes. Beſides the medicinal properties which characterize them, and which cauſe them to be employed in many caſes as very active and very valuable remedies: beſides their very multiplied effects, and their frequent uſe in the form of aromatic waters; beſides their application as ſtimulants, antiſeptics, and external catheretics, they form the principal ingredient of perfumes. They conſtitute all the odours that were formerly called ſpiritus rectors or perfumes; it is not only in their primitive ſtate of eſſences that they are employed in perfumery; they are combined for that purpoſe with fixed oils, with mucilages, with fecula, with alcohol, with vinegar, with fats. They are added to the powders, and the kinds of plants that are uſed for filling the perfuming bags, the *pots-pourris.* Their forms and modifications are varied in all poſſible ways.

They alſo enter into the compoſition of ſome fragrant ſubſtances for burning, or of aromatic paſtils.

They are mixed with a great number of liquors, in order to render them aromatic and agreeable, eſpecially the liquors uſed at table.

They are alſo employed as combuſtible bodies in ſome circumſtances.

They are uſed for preſerving dead bodies, and form part of the materials uſed in embalming.

Laſtly, They are ſometimes mixed with reſins and gum-reſins in the preparation of colours and pigments.

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